SOIL SURVEY

Pope County Minnesota

Issued October 1972

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1953–67. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the University of Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Pope Soil and Water Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Pope County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification and windbreak group. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units and windbreak groups.

Foresters and others can refer to the section "Field and Farmstead Windbreaks" where the soils of the county are grouped according to their suitability for trees and shrubs.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Wildlife and Recreation."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that give estimates of soil properties and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in the county will be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

U.S. GOVERNMENT PRINTING OFFICE: 1972

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Contents

Issued October 1972

This page intentionally left blank.

SOIL SURVEY OF POPE COUNTY, MINNESOTA

BY RAYMOND T. DIEDRICK, SOIL CONSERVATION SERVICE

SOIL SURVEYED BY R. T. DIEDRICK, J. C. HARRIES, P. L. LARSON, P. R. NYBERG, J. F. TORDSEN, R. R. LEWIS, AND H. C. LATVALA, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

POPE COUNTY is in the western part of Minnesota (fig. 1). It has a total land area of 435,840 acres, or 681 square miles. Glenwood is the county seat.

About 80 percent of the land area is farmed. Corn, soybeans, and small grains are the main crops. Hogs and feeder cattle are raised, and dairy herds are kept.

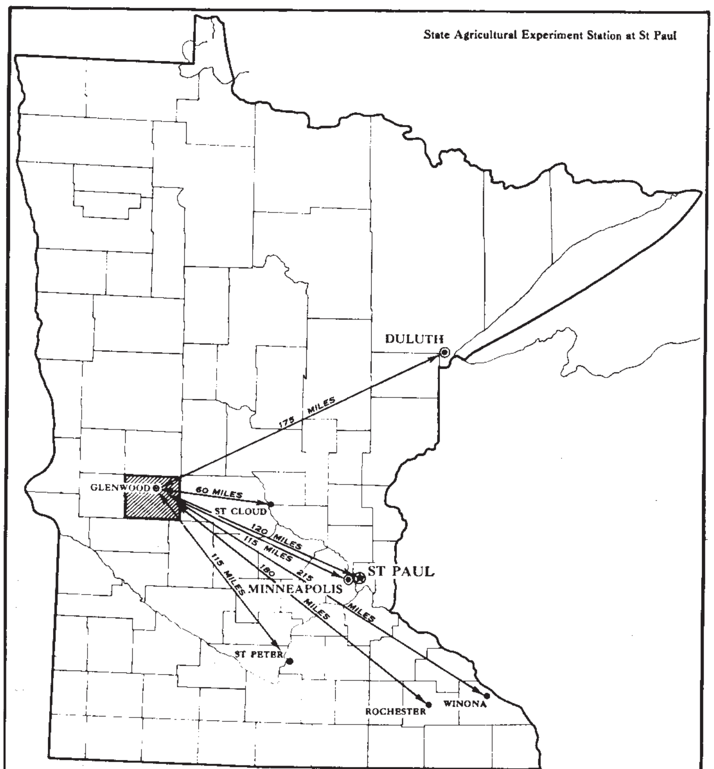

Figure 1.—Location of Pope County in Minnesota.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Pope County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide uniform procedures (*7*)[1]. To use this survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Langhei and Barnes, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Maddock sandy loam, 0 to 2 percent slopes, is one of several phases within the Maddock series.

After a guide for classifying and naming the soil had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

[1] Italicized numbers in parentheses refer to Literature Cited, page 107.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Pope County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Barnes-Langhei loams, 2 to 6 percent slopes, eroded, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Parnell and Flom silty clay loams is an example.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others; then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Pope County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The nine soil associations in Pope County are discussed in the following pages. The terms for texture used in the descriptive title for several of the associations apply to the surface layer. For example, in the descriptive title for association 1 the word "loamy" refers to texture of the surface layer.

1. Barnes-Langhei-Doland association

Deep, level to sloping, well-drained and somewhat excessively drained, loamy soils

This association consists dominantly of well-drained and somewhat excessively drained, gently sloping soils, but there are some small, level or depressional, poorly drained or very poorly drained areas and some small, steeply sloping areas. There are also several small, shallow lakes and many sloughs and marshes. This association occupies about 17 percent of the county and is located mainly in its northwestern part. The Barnes soils make up about 35 percent of the association; Langhei soils 18 percent; Doland soils 17 percent; and minor soils 30 percent.

The Barnes are well-drained, gently sloping soils that have a dark-colored surface layer. They formed in calcareous loam glacial till. The Langhei are somewhat excessively drained soils that formed in the same kind of material as the Barnes soils. Langhei soils have a thin, moderately dark, calcareous surface layer and are underlain by a strongly calcareous substratum. They are on the upper part of slopes or on sharp breaks in slopes. Doland soils are well-drained, level to gently sloping soils and are underlain by glacial till.

The minor soils are mainly the moderately well drained Tara soils; the moderately well drained Svea soils; the poorly drained Flom soils; the very poorly drained Parnell soils, which occur mainly in potholes; and the poorly drained and very poorly drained Tonka soils, which occur mainly in depressions in Walden Township.

About 80 percent of this association is subject to erosion. Erosion can be controlled by use of stripcropping, contour farming, and crop residue management. About 15 percent of the association needs additional drainage.

Most of this association is cultivated. Corn, soybeans, small grains, and alfalfa are the main crops. Hogs and feeder cattle are raised, and small dairy herds are kept.

2. Barnes-Langhei-Svea association

Deep, undulating to rolling, somewhat excessively drained to moderately well drained, loamy soils

This association is dominantly well drained and undulating, but some areas are somewhat excessively drained, some areas are poorly drained or very poorly drained and level or depressional, and some areas are steeply sloping. This association contains several marginal fishing lakes and many sloughs and marshes.

This association occupies 24 percent of the county and is located mainly in the terminal moraine area that extends from north to south through its central part. The Barnes soils make up about 50 percent of this association; the Langhei soils 20 percent; Svea soils 10 percent; and minor soils 20 percent.

The well-drained Barnes soils formed in calcareous loam glacial till. They have a dark-colored surface layer and are on the fairly uniform slopes. The Langhei soils formed in the same kind of material as the Barnes soils but are somewhat excessively drained, have a thin, moderately dark, calcareous surface layer, and are underlain by a strongly calcareous substratum. Langhei soils are on sharp breaks on slopes. The Svea soils are moderately well drained and formed in glacial till.

The minor soils are mainly the very poorly drained Parnell soils, which occur in deep depressions; the poorly drained Flom soils; the well-drained Waukon soils; the somewhat excessively drained Renshaw soils; and the excessively drained Sioux soils.

About 70 percent of this association is subject to erosion. Erosion can be controlled by use of stripcropping, contour farming, crop residue management, conservation cropping systems, and minimum tillage. About 15 percent of the association needs additional drainage.

Nearly all of this association is cultivated. Corn, soybeans, small grains, and alfalfa are the main crops. Hogs and feeder cattle are raised, and small dairy herds are kept.

3. *Langhei-Barnes association*

Deep, rolling to hilly, somewhat excessively drained and well-drained, loamy soils

This association consists mainly of somewhat excessively drained and well-drained soils but also contains numerous sloughs and marshes and small, poorly drained, level or depressional areas (fig. 2). The association occupies about 11 percent of the county; it is in the terminal moraine area in the southern part, and in areas that slope toward streams in the western part. The Langhei soils make up 60 percent of the association; Barnes soil 20 percent; and minor soils 20 percent.

The Langhei soils are somewhat excessively drained, have a thin, moderately dark, calcareous surface layer, and are underlain by a strongly calcareous substratum. Langhei soils occur on the upper parts of slopes. The Barnes are well-drained soils that have a dark-colored surface layer and occur on the more uniform slopes.

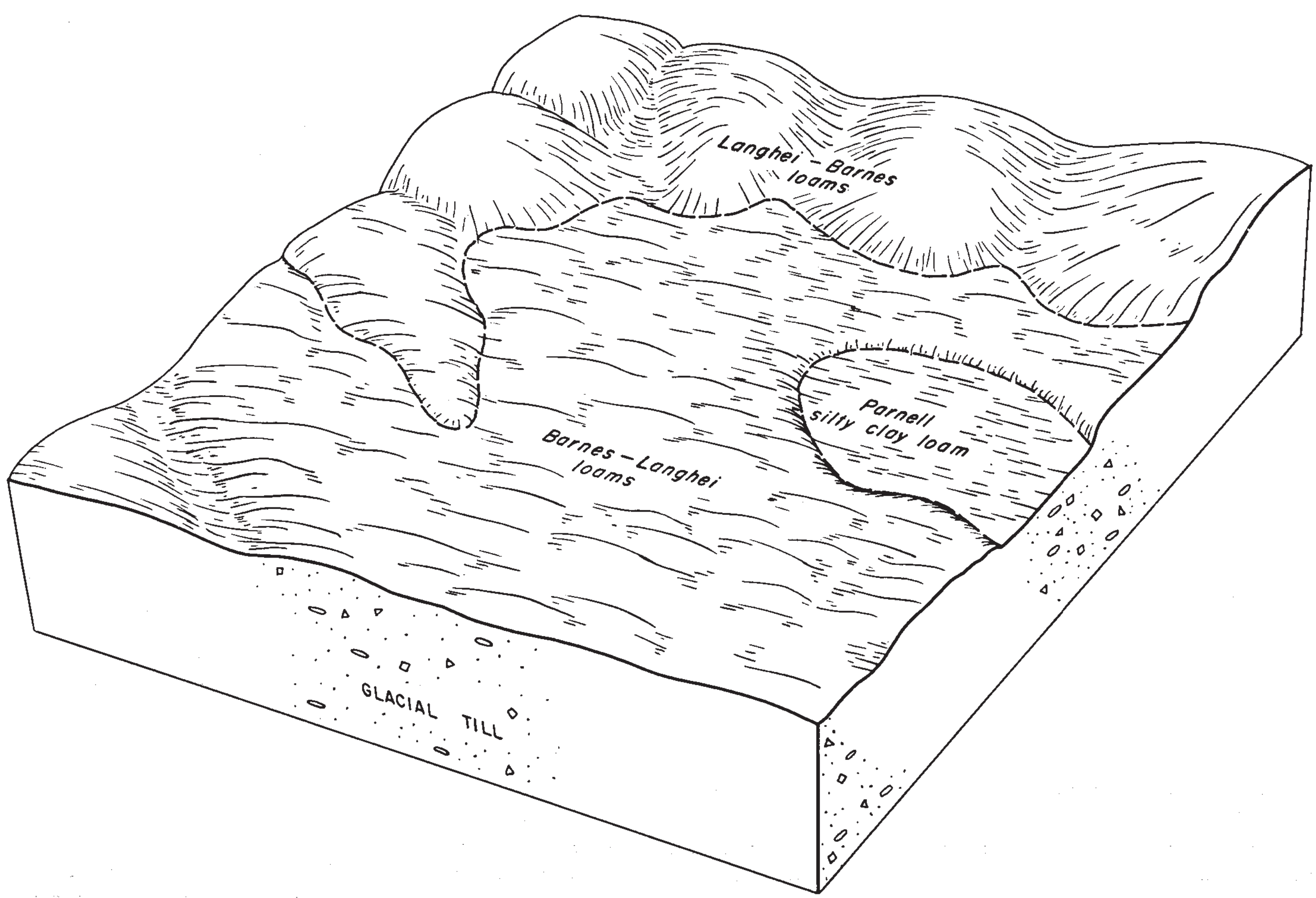

Figure 2.—Typical soil pattern in the Langhei-Barnes association.

The minor soils are the moderately well drained Svea soils; the poorly drained Flom soils in slight depressions; and the very poorly drained Parnell soils in enclosed potholes.

About 85 percent of this association is subject to erosion. Erosion can be controlled by use of conservation cropping systems, stripcropping, contour farming, and minimum tillage. About 15 percent of the association needs additional drainage.

Nearly all of this association is cultivated. Corn, soybeans, small grains, and alfalfa are the main crops. About 5 percent of the area is in permanent pasture. Hogs and feeder cattle are raised, and small dairy herds are kept.

4. *Langhei-Barnes-Waukon-Sioux association*

Deep and very shallow, hilly to steep, well-drained to excessively drained, loamy soils

This association is in the terminal moraine area in the southeastern part of the county and around Lake Minnewaska in the central part. It is mainly well drained to excessively drained but also contains some level and depressional wet areas, many marsh areas, some shallow lakes, and several fishing lakes. This association occupies about 7 percent of the county. The Langhei soils make up about 40 percent of it; Barnes soils 15 percent; Waukon soils 10 percent; Sioux soils 10 percent; and minor soils 25 percent.

The Langhei and Barnes soils occur together as a mapping complex. The Langhei are somewhat excessively drained soils that have a moderately dark colored, calcareous surface layer and are underlain by a strongly calcareous substratum. Langhei soils occur on the steepest slopes and on the hilltops. The Barnes are well-drained soils that have a dark-colored surface layer; they occur on the more uniform slopes in the association, and in many places are on the lower part of the slopes. The Waukon are well-drained soils; the Sioux are very shallow, excessively drained, droughty soils underlain by sand and gravel.

The minor soils are the poorly drained Flom soils in drainageways and shallow depressions; the very poorly drained Parnell and Muck soils in potholes and marshes; and the shallow, somewhat excessively drained Renshaw soils that are underlain by gravel.

About 85 percent of this association is subject to erosion. Erosion can be controlled on the more gentle slopes by use of conservation cropping systems, stripcropping, contour farming, terracing, and minimum tillage. The steeper slopes should be kept under permanent cover to control erosion. About 15 percent of the area is poorly drained or very poorly drained, and about 15 percent is droughty.

About 50 percent of this association is cultivated. Corn, soybeans, small grains, and alfalfa are the main crops. About 30 percent of the area is in permanent pasture; 10 percent is woodland; and 10 percent is marshland.

5. *Sioux-Maddock association*

Hilly to steep, mainly excessively drained soils that are very shallow over sand or gravel

This association is located in the terminal moraine area in the central part of the county (fig. 3). Included are some level, poorly drained areas, deeply set potholes, marshes, shallow lakes, and good fishing lakes. This association occupies about 3 percent of the county. Sioux soils make up about 70 percent of it; Maddock soils 10 percent; and minor soils 20 percent.

The Sioux are droughty soils that have a thin, dark-colored surface layer and are underlain by calcareous sand and gravel. The well-drained Maddock soils are deep and sandy.

The minor soils are the somewhat excessively drained Sverdrup, Renshaw, and Langhei soils and the well-drained Barnes soils.

About 95 percent of this association is subject to erosion. Erosion can be controlled by use of controlled grazing, conservation cropping systems, stripcropping, contour farming, crop residue management, and minimum tillage. About 95 percent of this association is droughty, and about 2 percent is wet.

About 90 percent of this association is under permanent grass and is used for pasture, and 10 percent is cultivated. Cultivated areas generally consist of small fields in the saddles between the hills. Corn, soybeans, and small grains are the main crops.

6. *Clarion-Canisteo-Nicollet association*

Deep, level to sloping, well-drained to very poorly drained, loamy soils

This association consists generally of well drained, gently sloping soils, but there are some small, level, moderately well drained and poorly drained areas and very poorly drained depressional areas, and some small, steeply sloping areas. Included are many wet marsh areas and a few shallow lakes. This association occupies about 6 percent of the county and is mainly in its northeastern part. The Clarion soils make up about 35 percent of the association; the Canisteo soils 20 percent; the Nicollet soils 15 percent; and minor soils 30 percent.

The Clarion are well-drained, sloping soils that formed in calcareous loam glacial till. These soils have a dark-colored surface layer and become calcareous at a depth of about 2 feet. The Nicollet are moderately well drained, level or nearly level, glacial till soils. The Canisteo are poorly drained and very poorly drained, calcareous, level or slightly depressional glacial till soils.

Among the minor soils are the depressional, very poorly drained Glencoe soils; the poorly drained Webster soils; the steep, somewhat excessively drained Storden soils; and the well-drained Waukon soils.

About 65 percent of this association is subject to erosion. Erosion can be controlled by use of stripcropping, contour farming, and crop residue management. About 30 percent of the association needs additional drainage.

Nearly 90 percent of this association is cultivated. Corn, soybeans, and small grains are the main crops. Hogs and feeder cattle are raised, and small dairy herds are kept.

7. *Estherville-Muck association*

Level, excessively drained soils that are shallow over sand and gravel, and very poorly drained organic soils

This association consists mainly of excessively drained, level soils, but there are large, elongated, marshy areas of muck soils, many small marsh areas, three good fishing

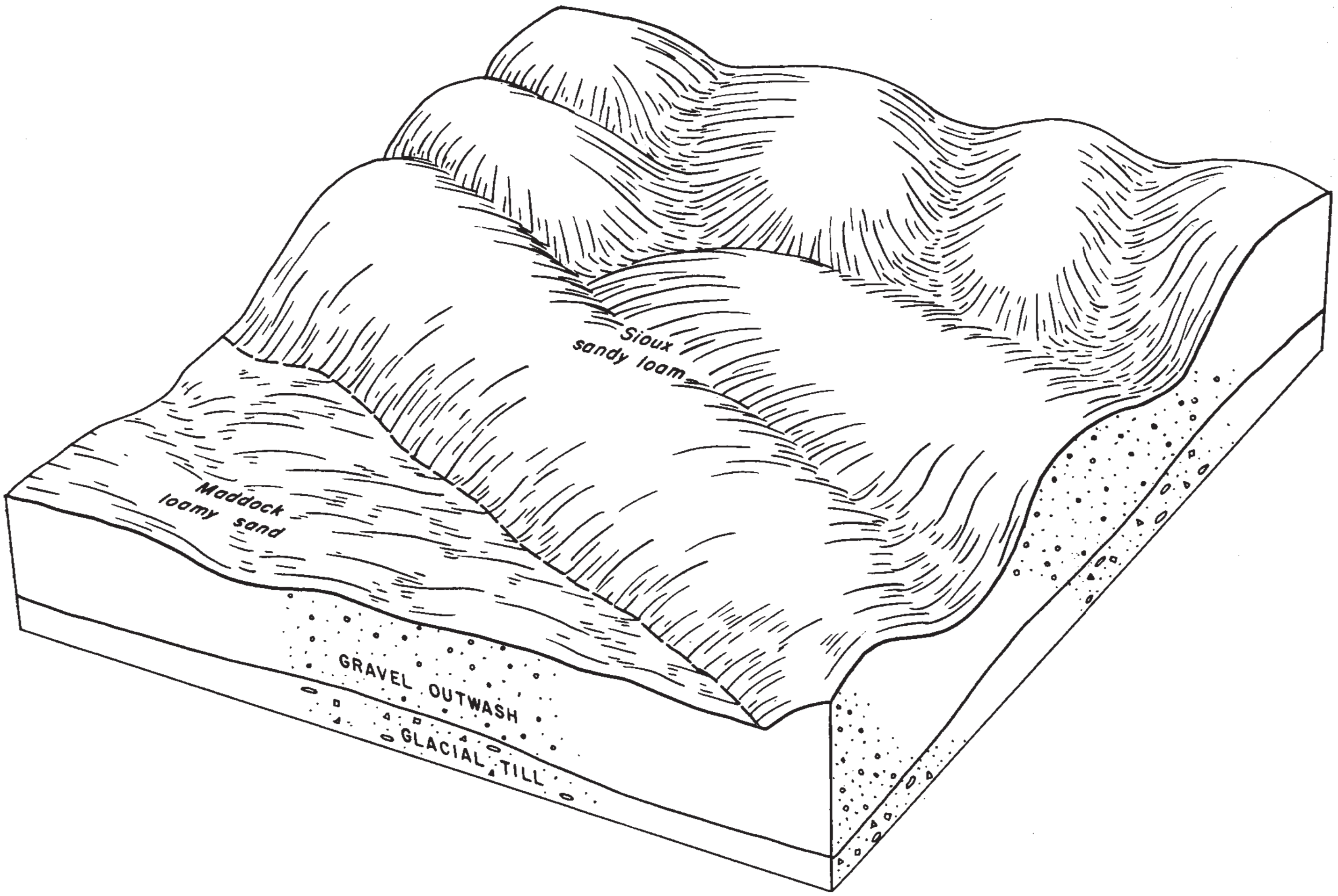

Figure 3.—**Typical soil pattern in the Sioux-Maddock association.**

lakes, and several shallow lakes. This association occupies about 21 percent of the county and occurs in the outwash area in its eastern third. The Estherville soils make up about 60 percent of the association; Muck soils 15 percent; and minor soils 25 percent.

The Estherville are shallow and droughty soils that consist of 12 to 24 inches of loam or sandy loam and are underlain by sand or gravel. Muck consists of organic soils of varying depth that generally are calcareous and are underlain by sand at a depth of 18 to 40 inches.

The minor soils are the very poorly drained Mayer soils in depressions; the poorly drained Mayer soils; the well-drained Wadena soils; and the excessively drained Salida soils.

About 80 percent of this association is subject to drought and soil blowing. Soil blowing can be controlled by use of wind stripcropping, field shelterbelts, crop residue management, and minimum tillage. Irrigation is practiced on several farms in the association. About 20 percent of the area is poorly drained or very poorly drained. Most of the muck soils are undrained because they lack an adequate outlet.

About 85 percent of this association is cultivated. Corn, soybeans, and small grains are the main crops. Hogs and feeder cattle are raised, and small dairy herds are kept.

8. *Renshaw-Estelline association*

Level to gently sloping, somewhat excessively drained to well-drained soils that are shallow to moderately deep over sand or gravel

This association consists mostly of somewhat excessively drained to well-drained, nearly level soils, but includes some poorly drained level areas and some gravelly, hilly areas. It occupies about 8 percent of the county and occurs in its western part, adjacent to the Chippewa River. The Renshaw soils make up about 40 percent of the association; the Estelline soils 20 percent; and minor soils 40 percent.

The Renshaw are somewhat excessively drained soils that are shallow and droughty that consist of 12 to 24 inches of loam or sandy loam underlain by sand or gravel. The Estelline are moderately deep, well-drained soils that consists of 24 to 40 inches of silt loam underlain by sand and gravel.

The minor soils are well-drained Fordville, Flandreau, and Maddock soils; the somewhat excessively drained Sverdrup soils; and the poorly drained Mayer soils.

About 85 percent of this association is subject to soil blowing and drought. Soil blowing can be controlled by use of wind stripcropping, field shelterbelts, crop residue management, and minimum tillage. About 15 percent of the area is poorly drained or very poorly drained. Some wet areas are very difficult to drain because they lack an adequate outlet.

Nearly 90 percent of this association is cultivated. Corn, soybeans, and small grains are the main crops. Hogs and feeder cattle are raised, and small dairy herds are kept.

9. Marysland-Muck-Arveson association

Level, poorly drained and very poorly drained soils that are shallow to moderately deep over sand, and very poorly drained organic soils

This association is located mainly in the southwestern part of the county. Part of it, however, is in the flat valley just west of Lake Minnewaska, where several large areas of Muck soils are located. It is mainly poorly drained and very poorly drained, but included in this area are some droughty, sandy, gently sloping soils and some very poorly drained, depressional soils. This association occupies about 3 percent of the county. Marysland soils make up about 40 percent of it; Muck soils 20 percent; Arveson soils 15 percent; and minor soils 25 percent.

The Marysland soils consist of poorly drained, calcareous loam and are underlain by sand at a depth of 24 to 40 inches. The Muck soils are calcareous, very poorly drained soils that are dominantly 18 to 40 inches deep over loam; they are located mainly in the area west of Lake Minnewaska. The Arveson soils consist of poorly drained, calcareous sandy loam and are underlain by sand at a depth of 12 to 24 inches.

The minor soils are the poorly drained Mayer and Colvin soils; the very poorly drained Colvin soils, depressional; the moderately well drained Hecla and Malachy soils; the somewhat excessively drained Renshaw soils; and the well drained Maddock soils.

About 80 percent of this association is subject to soil blowing. Soil blowing can be controlled by use of wind stripcropping, field shelterbelts, crop residue management, and minimum tillage. Droughtiness is a severe problem in about 20 percent of the area.

About 85 percent of this association is poorly drained or very poorly drained. Shallow ditches are commonly used to provide additional drainage. Use of tile drainage is risky on the soils that have a sand substratum. Many wet areas, particularly the Muck soils west of Lake Minnewaska, are very difficult to drain because they lack an adequate outlet.

About 75 percent of this association is cultivated. Corn, soybeans, and small grains are the main crops. Hogs and feeder cattle are raised.

Descriptions of the Soils

This section describes the soil series and mapping units of Pope County. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

In the pages that follow, a general description of each soil series is given. Each series description has a detailed description of a profile typical of the series and a brief statement of the range in characteristics of the soils in the series, as mapped in this county. Following the series description, each mapping unit in the series is described individually. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. Miscellaneous land types, such as Alluvial land, are described in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. At the end of the description of each mapping unit are listed the capability unit and the windbreak group in which the mapping unit has been placed. The page where each capability unit is described can be found readily by referring to the "Guide to Mapping Units."

Descriptions, names, and delineations of soils in this soil survey do not fully agree with soil maps in adjacent counties published at a different date. Differences are the result of better knowledge of soils, modifications in series concepts, intensity of mapping, and the extent of soils within the survey area. In some places it is more feasible to combine small acreages of similar soils that respond to use and management in much the same way than it is to separate these soils and give them names.

For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. Many of the terms used in the soil descriptions and other parts of the survey are defined in the Glossary.

Alluvial Land

Alluvial land (0 to 2 percent slopes) (Af) consists of dark-colored soil material that has been recently deposited by rivers and other streams. It is in areas that are adjacent to streams and are 1 to 3 feet higher than the normal water level. These areas are dissected by many old stream channels.

The soil material ranges in texture from coarse sand to silt loam and varies considerably within short distances. In places this material has a thin mucky surface layer. The underlying material generally is sand.

This land is mostly poorly drained, but in some areas it is very poorly drained or moderately well drained. Flooding occurs frequently in the spring and during periods of excessive rainfall. The water table is at the surface in the early part of the year and is at a depth of 1 to 2 feet by late in summer.

The areas of old stream channels are impractical to drain because they are so close to the streams. Water generally remains standing for long periods. This land is suitable for use as woodland, pasture, or wildlife habitat. Areas in pasture commonly are hummocky. (Capability unit VIw-1; windbreak suitability group 10)

Arveson Series

The Arveson series consists of poorly drained level or slightly depressional soils that are shallow over sand. These soils developed in calcareous loamy material overlying calcareous outwash sand. They occur in Hoff Township.

In a representative profile, the surface layer is calcareous, black to very dark gray sandy loam about 12 inches thick. The upper part of the underlying material is strongly calcareous, dark grayish-brown sandy loam. The lower part is grayish-brown, pale-olive, and light brownish-gray medium and fine sand that is mottled and strongly calcareous to calcareous.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent
Alluvial land	1, 120	0. 3
Averson sandy loam	1, 705	. 4
Barnes loam, 0 to 2 percent slopes	2, 335	. 5
Barnes-Langhei loams, 2 to 6 percent slopes, eroded	63, 440	14. 5
Barnes-Langhei loams, 6 to 12 percent slopes, eroded	19, 700	4. 4
Barnes-Langhei-Renshaw loams, 2 to 6 percent slopes, eroded	725	. 2
Barnes-Langhei-Renshaw loams, 6 to 12 percent slopes	995	. 2
Bearden silt loam, 0 to 2 percent slopes	540	. 1
Blue Earth silt loam	1, 530	. 4
Canisteo loam	2, 575	. 6
Clarion loam, 2 to 6 percent slopes	8, 855	2. 0
Clarion loam, 6 to 12 percent slopes, eroded	1, 310	. 3
Clontarf sandy loam, 0 to 2 percent slopes	620	. 1
Colvin silty clay loam	2, 030	. 5
Colvin silty clay loam, depressional	1, 315	. 3
Darnen silt loam, 0 to 4 percent slopes	1, 745	. 4
Dickinson sandy loam, 0 to 2 percent slopes	1, 275	. 3
Dickinson sandy loam, 2 to 6 percent slopes	925	. 2
Doland silt loam, 0 to 2 percent slopes	3, 280	. 8
Doland silt loam, 2 to 6 percent slopes	3, 925	. 9
Estelline silt loam, 0 to 3 percent slopes	2, 440	. 6
Estelline silt loam, moderately well drained variant	2, 010	. 5
Estherville loam, 0 to 2 percent slopes	23, 965	5. 5
Estherville loam, 2 to 6 percent slopes	24, 805	5. 7
Estherville loam, 6 to 12 percent slopes, eroded	2, 685	. 6
Estherville loam, thick solum, 0 to 2 percent slopes	6, 360	1. 5
Estherville loam, thick solum, 2 to 6 percent slopes	930	. 2
Flandreau silt loam, 0 to 2 percent slopes	860	. 2
Flandreau silt loam, 2 to 6 percent slopes	750	. 2
Fordville loam, 0 to 2 percent slopes	2, 290	. 5
Fordville loam, 2 to 6 percent slopes	835	. 2
Forman clay loam, 2 to 6 percent slopes, eroded	640	. 1
Forman clay loam, 6 to 12 percent slopes, eroded	165	(1)
Glencoe silty clay loam	3, 090	. 7
Hamar sandy loam	295	(1)
Hamerly loam, 0 to 3 percent slopes	4, 980	1. 1
Hecla loamy sand, 0 to 3 percent slopes	600	. 1
Lake beaches, loamy	990	. 2
Lake beaches, sandy	2, 030	. 5
Lamoure silt loam	1, 130	. 3
Lamoure silt loam, wet	1, 130	. 3
Lamoure complex	745	. 2
Langhei loam, 18 to 25 percent slopes	4, 650	1. 1
Langhei loam, 25 to 40 percent slopes	1, 340	. 3
Langhei stony loam, 6 to 40 percent slopes	915	. 2
Langhei-Barnes loams, 2 to 6 percent slopes, eroded	3, 920	. 9
Langhei-Barnes loams, 6 to 12 percent slopes, eroded	15, 925	3. 7
Langhei-Barnes loams, 12 to 18 percent slopes, eroded	15, 790	3. 6
Langhei-Barnes-Sioux complex, 12 to 18 percent slopes, eroded	755	. 2
Maddock loamy sand, 6 to 12 percent slopes	890	. 2
Maddock loamy sand, 12 to 25 percent slopes	2, 030	. 5
Maddock sandy loam, 0 to 2 percent slopes	365	(1)
Maddock sandy loam, 2 to 6 percent slopes	595	. 1
Malachy sandy loam, 0 to 2 percent slopes	685	. 2
Marsh	5, 565	1. 3
Marysland loam	4, 470	1. 0
Mayer loam	8, 810	2. 0
Mayer loam, depressional	6, 445	1. 5
Mayer loam, sandy subsoil variant	1, 675	. 4
McIntosh silt loam, 0 to 2 percent slopes	585	. 1
Muck	12, 580	2. 9
Muck, calcareous	2, 350	. 5
Muck, calcareous, seeped	775	. 2
Muck, calcareous, over loam	2, 415	. 1
Muck, calcareous, over sand	580	. 1
Muck over loam	6, 500	1. 5
Muck over sand	2, 820	. 6
Nicollet loam, 0 to 3 percent slopes	3, 280	. 8
Nutley silty clay loam, 0 to 2 percent slopes	500	. 1
Nutley silty clay loam, 2 to 6 percent slopes	90	(1)
Oldham silty clay loam	1, 335	. 3
Osakis sandy loam, 0 to 2 percent slopes	1, 150	. 3
Parnell silty clay loam	17, 970	4. 1
Parnell and Flom silty clay loams	18, 855	4. 3
Perella silty clay loam	1, 075	. 2
Renshaw loam, 0 to 2 percent slopes	4, 180	1. 0
Renshaw loam, 2 to 6 percent slopes	6, 445	1. 5
Renshaw loam, 6 to 12 percent slopes, eroded	2, 000	. 5
Salida sandy loam, 0 to 6 percent slopes	6, 720	1. 5
Salida sandy loam, 6 to 12 percent slopes, eroded	3, 325	. 8
Salida gravelly sandy loam, 12 to 35 percent slopes	2, 475	. 6
Sioux sandy loam, 0 to 6 percent slopes	1, 620	. 4
Sioux sandy loam, 6 to 12 percent slopes, eroded	1, 775	. 4
Sioux gravelly sandy loam, 6 to 35 percent slopes	6, 385	1. 5
Storden-Clarion loams, 12 to 25 percent slopes, eroded	380	. 1
Svea loam, 0 to 2 percent slopes	9, 060	2. 1
Svea loam, 2 to 4 percent slopes	2, 585	. 6
Sverdrup loam, 0 to 2 percent slopes	1, 545	. 4
Sverdrup sandy loam, 2 to 6 percent slopes, eroded	3, 985	. 9
Sverdrup sandy loam, 6 to 12 percent slopes, eroded	1, 705	. 4
Tara silt loam, 0 to 3 percent slopes	5, 255	1. 2
Tonka silt loam	485	. 1
Vallers silty clay loam	8, 295	1. 9
Wadena loam	1, 350	. 3
Waukon loam, 0 to 2 percent slopes	690	. 2
Waukon loam, 2 to 6 percent slopes	2, 600	. 6
Waukon loam, 6 to 12 percent slopes	1, 460	. 3
Waukon loam, 12 to 18 percent slopes	1, 570	. 4
Waukon clay loam, 2 to 6 percent slopes, eroded	1, 240	. 3
Waukon clay loam, 6 to 12 percent slopes, eroded	635	. 1
Webster loam	2, 700	. 6
Winger silty clay loam	925	. 2
Gravel pits	415	. 1
Water	2, 680	. 6
Total	435, 840	100. 0

[1] Less than 0.1 percent.

The organic-matter content is high, but natural fertility and available water capacity are low. Permeability is moderately rapid in the surface layer and rapid in the underlying sand. The high lime content causes an imbalance of available plant nutrients. The water table is high, and this limits the zone of root development.

Most of the acreage of these soils is farmed. Wetness and low fertility are the major limitations.

Following is a representative profile of a nearly level Arveson sandy loam, located in a cultivated field, 400 feet west and 200 feet south of the NE. corner of sec. 33, T. 123 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1—8 to 12 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C1ca—12 to 15 inches, dark grayish-brown (2.5Y 4/2) sandy loam; strongly calcareous; gradual, smooth boundary.

IIC2—15 to 26 inches, grayish-brown (2.5Y 5/2) medium and fine sand; common, fine, distinct, strong-brown and yellowish-brown mottles; single grain; loose; strongly calcareous; gradual, smooth boundary.

IIC3ca—26 to 36 inches, pale-olive (5Y 6/3) medium and fine sand; common, fine, distinct, strong-brown and yellowish-brown mottles; single grain; loose; strongly calcareous; contains manganese concretions; gradual, smooth boundary.

IIC4—36 to 60 inches, light brownish-gray (2.5Y 6/2) medium and fine sand; many, large, prominent, strong-brown and yellowish-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 8 to 14 inches in thickness and is calcareous or strongly calcareous. This horizon generally is sandy loam, but in small areas it is loam. The zone of maximum lime accumulation is 9 to 30 inches thick and is directly below the A horizon. Depth from the soil surface to the underlying sand is 13 to 20 inches. The underlying sand is chiefly medium but includes some fine and coarse sand.

The Arveson soils are more shallow over sand than the Marysland soils. Typically, they are calcareous throughout the profile, whereas the Hamar soils are free of lime in the A and B horizons.

Arveson sandy loam (0 to 2 percent slopes) (As).—This soil is in areas that are broad and irregular in shape and that lie in a northwest-southeast direction. The surface layer generally is 12 to 14 inches thick, but in some places it is less than 12 inches thick.

This soil occurs closely with the nearly level to gently sloping Hecla and Malachy soils and with the Mayer, depressional, soil. In places it occupies areas that are interfingered with areas of the poorly drained Hamar and Marysland soils. Included with this soil in mapping are small areas of the Marysland, Hamar, and Hecla soils.

This soil has a fluctuating water table that is within 2 feet of the surface early in summer but falls to a depth of about 5 feet by late in summer. Most areas of this soil have been drained by surface ditches, but wetness persists. Soil blowing is a severe hazard in unprotected fields during winter and spring.

All the common crops are grown on this soil. Management is needed to control soil blowing and to maintain a high level of plant nutrients. Applications of phosphorus and potassium are needed to offset effects of the high lime content. (Capability unit IIIw-4; windbreak suitability group 7)

Barnes Series

The Barnes series consists of deep, well-drained soils that have developed in calcareous loam glacial till. These nearly level to rolling soils are in the western two-thirds of the county.

In a representative profile, the surface layer is neutral, black loam about 8 inches thick. The subsoil is neutral loam about 11 inches thick. The upper part is very dark grayish brown, and the lower part is dark grayish brown. The underlying material is calcareous, light olive-brown loam.

The organic-matter content, available water capacity, and natural fertility are high, but permeability is moderate. Erosion control and fertility management are the major concerns in using these soils.

Most areas of Barnes soils are under cultivation. Most crops grow well if rainfall is adequate and proper management is practiced.

Following is a representative profile of a Barnes loam having a slope of 4 percent, located 30 feet west, 135 feet north, and 390 feet west of the SE. corner of the SW¼ SE¼ sec. 26, T. 126 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, dark gray when dry; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B1—8 to 13 inches, very dark grayish-brown (10YR 3/2) loam; weak, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

B2—13 to 19 inches, dark grayish-brown (10YR 4/2) loam; weak, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

C1ca—19 to 25 inches, light olive-brown (2.5Y 5/3) loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—25 to 60 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 7 to 12 inches in thickness. Its texture is loam, silt loam, or clay loam. The B horizon is 5 to 14 inches thick, and it is loam or light clay loam. The C horizon is calcareous loam or clay loam. Lime is leached to a depth of 12 to 24 inches. A layer of lime accumulation 6 to 20 inches thick occurs beneath the B horizon. Pebbles and stones are common on and through the soil. In a few places, a continuous pebble band occurs within the soil.

The Barnes soils have a thicker solum than the Langhei soils, which do not have a B horizon. They developed in a glacial till, whereas the Doland soils developed in sorted silt.

Barnes loam, 0 to 2 percent slopes (BaA).—This nearly level soil occurs mainly in the northwestern part of the county. Slopes are uniform and slightly convex. The soil areas are mostly somewhat circular in shape, but often are irregular.

Included with this soil in mapping are small areas of the Doland, Svea, Tara, Hamerly, and Parnell and Flom soils. Grayish spots of the Hamerly soils are in the slightly elevated areas. In some places this soil has a well-sorted, silt loam surface texture.

This soil is used mostly for growing corn, soybeans, and small grains. It is moderately well to well suited to these crops. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to maintain good soil tilth and a high level of fertility, and to control erosion. (Capability unit I-1; windbreak suitability group 1)

Barnes-Langhei loams, 2 to 6 percent slopes, eroded (BbB2).—The undulating soils that make up this complex occur in such intricate patterns that they were not mapped separately. These soils are in the western two-thirds of the county and occupy slopes ranging from 75 to 200 feet in length. Barnes loam makes up 80 percent of the individual areas, and Langhei loam, about 20 percent.

The Barnes soil has the profile described as representative for the series. It occurs on the more uniform slopes. On the upper part of the slopes, much of the original surface layer has been removed by erosion, and in these places the plow layer has a brownish color because some of the brown subsoil has been mixed with the remaining surface soil. In places near the bottom of the slopes, where soil material has accumulated, the present surface layer is thicker than normal.

The Langhei soil is on the tops of the slopes or on the slight rises above the more uniform slopes. The surface layer of this soil is grayish in color because tillage has mixed the original surface layer with the lighter colored subsoil.

Included with these soils in mapping are small areas of Doland silt loam, Darnen silt loam, Svea loam, Parnell and Flom soils, and Vallers silty clay loam. Also included in a few places in Minnewaska Township are small areas of Waukon soils and in some places in northern Langhei Township, areas of this soil that has a clay loam surface layer.

All the common crops are grown on the soils of this complex. The Barnes soil, however, is better suited to crops than the Langhei soil because the Langhei has a high content of lime that causes an imbalance of plant nutrients. Soil blowing is a slight hazard on fields left bare during winter and spring. Water erosion is a moderate hazard. Management is needed to maintain a high level of organic matter and plant nutrients and to control erosion. (Both soils, capability unit IIe–1; Barnes soil, windbreak suitability group 1; Langhei soil, windbreak suitability group 5)

Barnes-Langhei loams, 6 to 12 percent slopes, eroded (BbC2).—The rolling soils that make up this complex are so closely intermingled that they were not mapped separately. These soils are in the western two-thirds of the county and occupy irregular slopes ranging from 75 to 250 feet in length. Barnes loam makes up about 60 percent of the area, and Langhei loam, about 40 percent.

The Barnes soil has the more uniform slopes. On most of the slopes and especially the upper parts, the surface layer of the Barnes soil has been mixed with some of the subsoil, and this gives these areas a brownish color. In places at the base of the slopes and in the waterways, where soil material has accumulated, the surface layer is thicker than normal.

The Langhei soil is on the crests of the hills and the slight rises on the slopes. This soil is grayish in color because tillage has mixed the original surface layer with part of the lighter colored subsoil.

Included with this unit in mapping are small areas of Doland silt loam and Svea loam. Also included are some areas where the Barnes soil has been only slightly eroded and some places in northern Langhei Township where the surface layer is clay loam.

All crops common in the county are grown on the soils of this complex; however, planting row crops creates a severe hazard of water erosion. Soil blowing is a hazard in fields left unprotected during winter and spring. The organic-matter content and infiltration rate of these soils have been reduced because of erosion. The Barnes soil is better suited to crops than the Langhei soil. Management is needed to control erosion and to maintain a high level of organic matter and plant nutrients. (Both soils, capability unit IIIe–1; Barnes soil, windbreak suitability group 1; Langhei soil, windbreak suitability group 5)

Barnes-Langhei-Renshaw loams, 2 to 6 percent slopes, eroded (BdB2).—These undulating, moderately eroded soils occur mainly throughout the central part of the county, but they are also in the western two-thirds of the county. The slopes range from 75 to 200 feet in length. Barnes loam makes up about 65 percent of the individual areas; Langhei loam, 20 percent; and Renshaw loam, 15 percent.

The Barnes soil occurs on the more uniform slopes. On the upper part of the slopes, the surface layer of the Barnes soil has been mixed with part of the subsoil, and it gives these areas a brownish color. On the lower parts of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

The Langhei soil is light colored and highly calcareous, and it occurs on the rises. The Renshaw soil is dark colored and occurs on the slight rises. Included with these soils in mapping are small areas of the Svea and Fordville soils.

All the crops common in the county are grown on the soils of this complex. The Barnes soil is moderately well suited to well suited to crops, but the highly calcareous Langhei and the droughty Renshaw soils are poorly suited to crops. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to maintain a high level of organic matter and plant nutrients, and to control erosion. (All three soils, capability unit IIe–1; Barnes soil, windbreak suitability group 1; Langhei soil, windbreak suitability group 5; Renshaw soil, windbreak suitability group 6)

Barnes-Langhei-Renshaw loams, 6 to 12 percent slopes (BdC).—The rolling, moderately eroded soils that make up this complex occur mainly in the terminal moraine areas in the western two-thirds of the county. Slopes are irregular and range from 75 to 250 feet in length. Barnes loam makes up about 45 percent of the soil areas; Langhei loam, 30 percent; and Renshaw loam, 25 percent.

The Barnes soil has a brownish-colored surface layer, and it surrounds the Langhei soil, which generally occupies the upper slopes. The Langhei loam is grayish colored and highly calcareous. The Renshaw soil often has stones on the surface. At the base of the slopes and in the draws, where soil material has accumulated, the surface layer is thicker than normal. Included with these soils in mapping are small areas of Svea and Darnen soils.

All the common crops in the county are grown on soils of this complex. These soils are moderately well suited to poorly suited to crops. Water erosion is a moderate hazard. Management is needed to control erosion and maintain a high level of organic matter and plant nutrients. (All three soils, capability unit IVe–1; Barnes soil, windbreak suitability group 1; Langhei soil, windbreak suitability group 5; Renshaw soil, windbreak suitability group 6)

Bearden Series

The Bearden series consists of deep, moderately well drained to somewhat poorly drained, calcareous soils that have developed in moderately fine textured material laid down by water. These level to nearly level soils occur in the eastern part of Hoff and the southern part of White Bear Lake Townships.

In a representative profile, the surface layer is calcareous to strongly calcareous, mostly black silt loam about 16 inches thick. The upper part of the underlying material is strongly calcareous, dark grayish-brown and grayish-brown to light olive-brown silt loam about 8 inches thick. The lower part is calcareous, mottled, light grayish-brown silt loam in the upper 4 inches and is light olive-brown and grayish-brown silty clay loam that extends to a depth of 60 inches.

The organic-matter content and available water capacity are high. However, natural fertility is only moderate because the high lime content of the soil causes an imbalance of available plant nutrients. Permeability is moderate. Normally the water table is low, and this allows crops to establish an adequate root zone. However, during long rainy periods the water table rises high enough to limit the zone of root development.

These soils are generally farmed to corn and soybeans, to which they are well suited.

Following is a representative profile of Bearden silt loam, 0 to 2 percent slopes, located in a nearly level cultivated field, 200 feet west and 200 feet north of field approach in the SW¼SE¼ sec. 36, T. 125 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, coarse, angular blocky structure; friable; calcareous; abrupt, smooth boundary.

A11—8 to 14 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

A12ca—14 to 16 inches, very dark grayish-brown (2.5Y 3/1) silt loam; weak, coarse, prismatic structure breaking to weak, medium and fine, subangular blocky; friable; strongly calcareous; gradual, smooth boundary.

C1ca—16 to 20 inches, dark grayish-brown (2.5Y 4/2) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky; friable; strongly calcareous; gradual, smooth boundary.

C2ca—20 to 24 inches, grayish-brown (2.5Y 4/3) to light olive-brown (2.5Y 5/4) silt loam; few, fine, faint, light olive-brown mottles; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky; friable; tongues of black extend to a depth of 22 inches; strongly calcareous; gradual, smooth boundary.

C3—24 to 28 inches, light grayish-brown (2.5Y 5/3) silt loam; common, fine, faint, light olive-brown mottles; weak, coarse, prismatic structure breaking to moderate, medium, subangular blocky; friable; calcareous; clear, smooth boundary.

C4—28 to 38 inches, light olive-brown (2.5Y 5/4) silty clay loam; common, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

C5—38 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, moderate, distinct, yellowish-brown and strong-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A and C horizons range from silt loam to silty clay loam. The combined thickness of the Ap and A1 horizons ranges from 8 to 15 inches. Generally, the soil profile is calcareous to strongly calcareous. Gypsum and manganese concretions are common in the C horizon in most places.

The Bearden soils are more brownish in the A3 and Cca horizons than the Colvin soils. Typically, they are silty throughout the profile, whereas the C horizon of the McIntosh soils is loam.

Bearden silt loam, 0 to 2 percent slopes (Be).—This level to nearly level soil has a slightly convex surface. It occurs closely with the Colvin, Perella, Winger, McIntosh, and Colvin, depressional, soils.

Included with this soil in mapping are small areas of the Colvin and Colvin, depressional, soils. The Colvin soil is in the level, slightly lower areas, and the Colvin, depressional, soil is in the wet depressions. In some places the surface layer of the Colvin and Colvin, depressional, soils is strongly calcareous or it may be noncalcareous to a depth of about 12 inches. Also included is 150 acres in which the underlying material is fine or very fine sand. In places glacial till occurs at a depth of less than 40 inches.

This Bearden soil is moderately well suited to well suited for growing corn and soybeans. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control erosion and maintain a high level of plant nutrients. Applications of nitrogen, phosphorus, and potassium are also needed. (Capability unit IIe-4; windbreak suitability group 5)

Blue Earth Series

The Blue Earth series consists of deep, very poorly drained soils that developed in calcareous, highly organic silty sediments. These soils are in large circular or elongated depressions throughout the county.

In a representative profile, a layer of calcareous muck about 8 inches thick occurs on the mineral soil. The surface layer is strongly calcareous to calcareous, very dark gray and black silt loam high in organic matter in the upper 20 inches. The lower 8 inches of the surface layer is very dark gray loam. Snail shells are common throughout the muck and surface layers. The underlying material is calcareous, dark-gray sandy loam and sand that grade to gray loam below a depth of 36 inches. Prominent mottles occur in the lower part of the underlying material.

The organic-matter content and available water capacity are high, but natural fertility is only moderate because of the high lime content of the soils. Permeability is moderate. These soils have a very high water table, and this limits the zone of root development. Wetness and low fertility are the major limitations affecting use of these soils. With adequate drainage and proper soil management, the soils are moderately well suited to well suited to crops.

Following is a representative profile of Blue Earth silt loam, located in a meadow of reed canarygrass, 100 feet west and 100 feet south of field approach in the SE¼NW¼ sec. 25, T. 126 N., R. 39 W.

02—8 inches to 0, black (N 2/0) muck; friable; many snail shells; calcareous; abrupt, smooth boundary.

A11—0 to 9 inches, very dark gray (5Y 3/1) silt loam, highly organic; many, fine, distinct, dark-brown root stains; massive; friable; many snail shells; strongly calcareous; clear, smooth boundary.

A12—9 to 20 inches, black (5Y 2/1) silt loam, highly organic; many, fine, distinct, dark-brown root stains; moderate, fine, subangular blocky structure; friable; many snail shells; calcareous; gradual, wavy boundary.

A13—20 to 28 inches, very dark gray (5Y 3/1) loam, highly organic; many, fine, distinct, dark-brown root stains; weak, fine, subangular blocky structure; friable; many snail shells; strongly calcareous; gradual, wavy boundary.

C1g—28 to 36 inches, dark-gray (5Y 4/1) sandy loam and sand; massive; loose; calcareous; clear, smooth boundary.

C2—36 to 60 inches, gray (5Y 5/1) loam; moderate, medium, prominent, yellowish-brown and light olive-brown mottles; massive; friable; calcareous.

The A horizon includes highly organic silt loam and silty clay loam textures. A muck layer that is less than 12 inches thick generally is on top of the surface layer. Thin layers of moderately coarse textured material occur in the C horizon.

Blue Earth soils differ from Muck by having less organic matter. Typically, they are calcareous throughout the profile, whereas the Parnell soils are noncalcareous.

Blue Earth silt loam (0 to 2 percent slopes) (Bh).—This poorly drained soil is flooded in spring and generally throughout the year.

Included with this soil in mapping are small areas of Oldham silty clay loam and Vallers silty clay loam along the edge of the soil areas and in some places, small areas of Muck, calcareous, over loam.

Undrained, this soil is generally covered with reeds, sedges, rushes, and, in some places, stunted shrubs or trees. Areas that are in a marsh condition are shown on the soil map by wet symbols. These areas are well suited as wildlife habitat.

When drained, this soil is used for hay production, pasture, or growing crops, depending upon the type of drainage system used. Shallow ditches remove enough surface water that these areas are well suited to hay or pasture. Deep ditches drain surface water adequately to grow crops; however, wetness remains a hazard. A tile drainage system is needed for adequate drainage. If adequately drained, this soil is moderately well suited to growing all crops common in the county. Small grains, however, tend to lodge, and corn and soybeans generally do not reach maturity. Silage corn is well suited to this soil. Soil blowing is a hazard in fields left unprotected during winter and spring. (Capability unit IIIw-5; windbreak suitability group 10)

Canisteo Series

The Canisteo series consists of deep, poorly drained and very poorly drained soils that have developed in calcareous glacial till. These level and nearly level soils are in broad areas or on rims around potholes in the ground moraine areas in the eastern part of the county.

In a representative profile, the surface layer is calcareous loam that is black in the upper 16 inches and very dark gray in the lower 5 inches. The upper part of the underlying material is strongly calcareous, mottled, olive-gray loam. The lower part is calcareous, mottled, light olive-brown, olive-gray, and gray loam.

The organic-matter content and available water capacity are high, but permeability is moderate. Natural fertility is only moderate because of the high lime content of these soils. Early in the growing season, these soils have a high water table that limits the zone of root development.

These soils are farmed mostly to corn and soybeans. Wetness and an imbalance of plant nutrients are the limitations in using these soils.

Following is a representative profile of Canisteo loam having a slope of 1 percent, located 100 feet east, 125 feet north, and 700 feet west of the SE. corner of the SW¼ sec. 3, T. 126 N., R. 36 W.

Alp—0 to 8 inches, black (N 2/0) loam; moderate, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A12—8 to 16 inches, black (10YR 2/1) loam; weak, coarse, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

A13—16 to 21 inches, very dark gray (2.5Y 3/1) loam; weak, fine, subangular blocky structure; friable; calcareous; clear, irregular boundary.

Clca—21 to 26 inches, olive-gray (5Y 5/2) loam; many, fine, distinct, light olive-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—26 to 34 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, olive-gray and olive mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C3—34 to 40 inches, olive-gray (5Y 5/2) loam; many, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C4—40 to 60 inches, gray (5Y 5/1) loam; many, medium, prominent, yellowish-brown mottles; massive; friable; calcareous.

The A horizon ranges from 12 to 24 inches in thickness and is slightly to strongly calcareous. Its texture is loam, clay loam, or silty clay loam. The C horizon is loam or clay loam and is strongly mottled.

Typically, the Canisteo soils have a Cca horizon at a greater depth than the Vallers and Colvin soils. The solum of the Canisteo soils developed in glacial till, whereas the solum of the Winger soils developed in silty material overlying glacial till.

Canisteo loam (0 to 2 percent slopes) (Ca).—This soil is in broad, nearly level areas and on the rims around potholes. In some places the surface layer is strongly calcareous and more grayish in color than normal.

This soil occurs closely with the Nicollet and Webster soils. Small areas of these soils are included with this soil in mapping. Also included are some small, light-colored, slightly elevated areas of the Hamerly soils and some small, very poorly drained depressions.

This soil is farmed mostly to corn and soybeans. Most areas of this soil are drained by surface ditches. but wetness persists. If adequately drained, this soil is well suited to growing crops. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to control erosion, provide adequate drainage, and maintain a high level of plant nutrients. Applications of nitrogen and phosphorous are also needed to offset effects of the high lime content of the soil. (Capability unit IIw-2; windbreak suitability group 4)

Clarion Series

The Clarion series consists of deep, well-drained soils that have developed in calcareous loam glacial till. These nearly level to rolling soils are in the eastern part of the county.

In a representative profile, the surface layer is neutral, black loam in the upper 7 inches, and it grades to very dark brown loam in the lower 5 inches. The subsoil is neutral, very dark grayish-brown loam in the upper 5 inches and is brown loam in the lower 12 inches. The underlying material is mottled, light olive-brown loam. The upper few inches are neutral, and the remainder is calcareous.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate. Erosion control and fertility management are the main concerns in using these soils.

Most areas of these soils are under cultivation. They are well suited to crops if properly managed.

Following is a representative profile of Clarion loam having a slope of 4 percent, located 100 feet north of the approach to the school house in the SE¼SE¼SW¼ sec. 11, T. 124 N., R. 36 W.

A11—0 to 7 inches, black (10YR 2/1) loam; moderate, fine, granular structure; friable; neutral; gradual, wavy boundary.

A12—7 to 12 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B1—12 to 17 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—17 to 29 inches, brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1—29 to 33 inches, light olive-brown (2.5Y 5/3) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C2—33 to 40 inches, light olive-brown (2.5Y 5/3) loam; few, fine, distinct, light brownish-gray and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C3—40 to 60 inches, light olive-brown (2.5Y 5/4) loam; many, fine, distinct, light brownish-gray and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 8 to 14 inches in thickness and is loam or clay loam. The B horizon is 10 to 20 inches thick and is also loam or clay loam. Depth to free lime is 24 to 36 inches.

The Clarion soils have a thicker solum than the Storden soils. They developed in glacial till, whereas the Doland soils developed in sorted silts. The Clarion soils lack the textural B horizon that is present in the Waukon soils.

Clarion loam, 2 to 6 percent slopes (CmB).—This gently sloping soil is in the glacial till areas in the eastern part of the county. Slopes range from 75 to 250 feet in length. Areas of this soil are irregular in shape.

This soil has the profile described as representative for the series. In some places the upper part of the slopes is eroded. Here the surface layer has a brownish color because some of the dark-brown subsoil has been mixed with the surface layer. On the lower slopes, where soil material has accumulated, the surface layer is thicker than normal.

This soil occurs closely with Storden, Nicollet, and Webster soils. Small areas of these soils are included with this soil in mapping. The Storden soil occupies the higher positions in the soil areas. The Nicollet and Webster soils are in the lower areas. In Westport Township this Clarion soil has a well-developed subsoil with clay films. In parts of Grove Lake and Glenwood Townships, small areas of Waukon loam are included with this soil in some places.

All the common crops are grown on this Clarion soil. Water erosion is a hazard on some of the longer, steeper slopes. Crops are moderately well to well suited to this soil, but management is needed to control erosion and maintain high levels of organic matter and plant nutrients. (Capability unit IIe–1; windbreak suitability group 1)

Clarion loam, 6 to 12 percent slopes, eroded (CmC2).—This sloping and rolling soil is in the glacial till areas of the eastern part of the county. Slopes range from 75 to 250 feet in length.

This soil commonly is moderately eroded on the upper part of the slopes. Here, over one-third of the original surface layer has been removed. These areas have a brownish surface layer because some of the subsoil has been mixed with the remaining surface layer. On the lower slopes, where soil material has accumulated, the surface layer is thicker than normal. In Westport Township this soil has a well-developed subsoil with clay films. This soil occurs closely with the Storden, Nicollet, Webster, and Glencoe soils. Small areas of these soils are included with this soil in mapping. The Storden soils occupy the upper slopes and are light colored and highly calcareous.

All the common crops are grown on this Clarion soil. Water erosion is a moderate hazard. Management is needed to control erosion and maintain high levels of organic matter and plant nutrients. (Capability unit IIIe–1; windbreak suitability group 1)

Clontarf Series

The Clontarf series consists of deep, moderately well drained soils that have developed in outwash sands. These soils are nearly level or are level and slightly depressed. They occur mainly in Hoff Township.

In a representative profile, the surface layer is neutral, black to very dark gray sandy loam about 16 inches thick. The upper 4 inches of the subsoil is neutral, dark grayish-brown sandy loam. In the lower 3 inches it is slightly calcareous, mottled, olive-brown sandy loam. The underlying material is calcareous or strongly calcareous, mottled, light olive-brown loamy sand in the upper 7 inches. The lower part is calcareous, light olive-brown sand.

The organic-matter content is high, but natural fertility and available water capacity are low. Permeability is moderately rapid in the surface layer and subsoil, and rapid in the underlying material. Soil blowing and droughtiness are severe hazards in using these soils. However, most areas of these soils are under cultivation. They are moderately well suited to crops if rainfall is adequate and proper soil management is practiced.

Following is a representative profile of Clontarf sandy loam, 0 to 2 percent slopes, located in a nearly level cultivated field, 40 feet west and 440 feet SE. of the east-west fence along the railroad in the NW¼SW¼NW¼ sec. 19, T. 123 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; cloddy, breaking to weak, medium, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—8 to 13 inches, very dark gray (10YR 3/1) sandy loam; weak, medium, subangular blocky structure; friable; some black root hairs; neutral; gradual, wavy boundary.

A3—13 to 16 inches, very dark gray (10YR 3/1) sandy loam, very dark gray and dark grayish-brown when dry; weak, medium, prismatic structure breaking to weak, medium, subangular blocky; friable; neutral; gradual, wavy boundary.

B21—16 to 20 inches, dark grayish-brown (2.5Y 4/2) sandy loam; weak, medium, prismatic structure breaking to fine, weak, subangular blocky; friable; some light olive-brown wormcasts; neutral; gradual, wavy boundary.

B22—20 to 23 inches, olive-brown (2.5Y 4/4) sandy loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; slightly calcareous; gradual, wavy boundary.

C1—23 to 26 inches, light olive-brown (2.5Y 5/4) loamy sand; few, fine, faint, light brownish-gray and light yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2ca—26 to 30 inches, light olive-brown (2.5Y 5/3) loamy sand, light yellowish brown when dry; few, fine, faint, grayish-brown mottles; weak, coarse, subangular blocky structure; loose; strongly calcareous; gradual, wavy boundary.

C3—30 to 36 inches, light olive-brown (2.5Y 5/4) sand; few, fine, faint mottles; single grain; loose; calcareous; gradual, wavy boundary.

C4—36 to 60 inches, light olive-brown (2.5Y 5/4) sand; few, medium, distinct, yellowish-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 12 to 20 inches in thickness and is black to very dark gray sandy loam or loam. The C horizon is medium or fine sand. Depth to free lime is 18 to 24 inches, commonly near 20 inches.

The Clontarf soils have a thicker A horizon and a more olive color in the B horizon than the Maddock soils. They are more olive colored in the B horizon than the Sverdrup soils. They have a finer textured solum than the Hecla soils.

Clontarf sandy loam, 0 to 2 percent slopes (Cn).—This soil is in small areas that are somewhat elongated and generally lie in a southerly direction.

This soil has the profile described as representative for the series. It occurs closely with the Malachy, Hecla, Arveson, and Hamar soils, and small areas of these soils are included. Also included are some small, eroded, lighter colored areas, generally in the slightly higher positions. In some places the surface layer is loam. In some areas this soil has a thinner surface layer than is typical of this series.

Corn, soybeans, and small grains are commonly grown on this soil, which is poorly suited to moderately well suited to crops. Soil blowing is a hazard in unprotected fields during winter and spring. Droughtiness generally is a limitation late in summer. Management is needed to control erosion, conserve moisture, and maintain a high level of organic matter and plant nutrients. (Capability unit IIIs-3; windbreak suitability group 8)

Colvin Series

The Colvin series consists of calcareous, poorly drained soils that have developed in moderately fine textured, water-laid silty material. These soils are level to slightly depressional; they occur in the southeastern part of Hoff, the southern part of White Bear Lake, and the northeastern part of Grove Lake Townships.

In a representative profile, the surface layer is calcareous, black and very dark gray silty clay loam about 15 inches thick. The underlying material is mottled silty clay loam. The upper part is strongly calcareous and dark gray to olive gray. The lower part is calcareous and olive gray.

The organic-matter content and available water capacity are high, but natural fertility is moderate because the high lime content of the soil causes an imbalance of plant nutrients. Permeability is moderately slow. The water table is high during the early part of the growing season, and this limits the zone of root development.

Most areas of the Colvin soils are under cultivation. If adequately drained, these soils are well suited to crops.

Following is a representative profile Colvin silty clay loam in a cultivated field, located 90 feet north and 400 feet east of the SW. corner of the SE¼ sec. 11, T. 123 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1—8 to 15 inches, very dark gray (10YR 3/1) silty clay loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C1ca—15 to 21 inches, dark-gray (5Y 4/1) silty clay loam; light gray when dry; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, irregular boundary.

C2ca—21 to 25 inches, olive-gray (5Y 5/2) silty clay loam; many, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C3—25 to 30 inches, olive-gray (5Y 5/2) silty clay loam; many, medium, distinct, yellowish-brown mottles; some very dark grayish-brown root stains; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C4—30 to 60 inches, olive-gray (5Y 5/2) silty clay loam; many medium, prominent, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon is 8 to 16 inches thick and is silt loam or silty clay loam. Sulfate, manganese, and iron concretions commonly occur in the C horizon.

Typically, the Colvin soils are calcareous throughout the profile, whereas the Perella soils are noncalcareous to a depth of at least 18 inches. The Colvin soils are finer textured than the Marysland soils, more olive colored in the C horizon than the Bearden soils, and more silty than the Vallers soils.

Colvin silty clay loam (0 to 2 percent slopes) (Co).—This poorly drained soil is in areas that are broad and irregular but occasionally is in elongated waterways.

This soil has the profile described as representative for the series. It occurs closely with the Bearden, Perella, and Colvin, depressional, soils. Small areas of these soils are included with this soil in mapping. The Bearden soil is on the slightly elevated parts of the soil area and the Colvin, depressional, soil is in the wet depressions. In some places the surface layer is noncalcareous to a depth of 14 inches. In places there are pebbles and stones on the soil surface, and in a few places glacial till is at a depth of less than 40 inches.

This soil has a fluctuating water table that is within 2 feet of the surface in spring but falls to a depth of about 5 feet in fall. Most areas of this soil have been drained by surface ditches, but wetness persists. Tile drainage is needed to obtain adequate drainage. Soil blowing is a hazard in unprotected fields during winter and spring. This soil is farmed intensively to corn and soybeans. Management is needed to control soil blowing, maintain good soil tilth, and provide a high level of plant nutrients. Applications of nitrogen, phosphorus, and potassium are also needed. (Capability unit IIw-2; windbreak suitability group 4)

Colvin silty clay loam, depressional (0 to 2 percent slopes) (Cp).—This poorly drained soil is in depressions and potholes in the lacustrine areas of the county. It is flooded in spring and commonly throughout the year.

Included with this soil are small areas of Colvin or Winger silty clay loam along the outer edge of mapped areas and of Perella silty clay loam in the middle of the areas.

If this soil is undrained, it is generally covered with reeds, sedges, rushes, and, in some places, stunted shrubs or trees. Areas that are in marsh are shown on the soil map by wet symbols. These areas are suited for use as wildlife habitat.

When drained, this soil is used as hayland, pasture, or cropland, depending on the type of drainage system used. Shallow ditches remove enough surface water that the soil is well suited to hay or pasture. Deep ditches remove surface water adequately for crops; however, wetness remains a hazard. If adequately drained, this soil is moderately well suited to growing nearly all crops common in the county. Silage corn is well suited to this soil, but small grains tend to lodge, and corn and soybeans generally do not reach maturity. Soil blowing is a hazard in fields left unprotected during winter and spring. Applications of nitrogen, phosphorus, and potassium are needed. (Capability IIIw–2; windbreak suitability group 4)

Darnen Series

The Darnen series consists of deep, moderately well drained soils that have developed in material washed down from the nearby glacial till soils. Darnen soils are nearly level to gently sloping; they lie in drainageways or at the base of slopes.

In a representative profile, the surface layer is neutral, very dark grayish-brown silt loam about 20 inches thick. The subsoil is neutral, very dark grayish-brown loam about 13 inches thick. The underlying material is light olive-brown loam that is neutral in the upper few inches and calcareous in the lower part.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate. These soils are in areas that receive a considerable amount of runoff from higher areas. They are somewhat wetter than the adjacent sloping soils.

The Darnen soils are well suited to crops, but they generally occur in small areas and are farmed along with nearby soils.

Following is a representative profile of Darnen silt loam having a slope of 2 percent, located 800 feet west and 600 feet north in the center of sec. 1, T. 125 N., R. 40 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark gray (10YR 3/1) when crushed; cloddy, breaking to weak, fine, angular blocky structure; friable when moist; neutral; gradual, wavy boundary.

A1—7 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark gray (10YR 3/1) when crushed; weak, fine, angular blocky structure; very friable when moist; neutral; gradual, wavy boundary.

B21—20 to 28 inches, very dark grayish-brown (10YR 3/2) loam, very dark brown (10YR 2/2) when crushed; weak, moderate, angular blocky structure that shows slight vertical cleavage; friable when moist; neutral; gradual, wavy boundary.

B22—28 to 33 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, angular blocky structure; friable when moist; neutral; gradual, wavy boundary.

C1—33 to 38 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, angular blocky structure; friable when moist; neutral; gradual, wavy boundary.

C2—38 to 60 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, angular blocky structure; friable when moist; calcareous.

The A horizon ranges from 18 to 28 inches in thickness, but normally it is near 20 inches thick. This horizon is loam or silt loam. Depth from the soil surface to free lime ranges from 16 to 40 inches. Sand grains and stones are common, and in some places thin lenses of sand occur in the profile.

Typically, the Darnen soils have a thicker A1 horizon than the Svea or Tara soils.

Darnen silt loam, 0 to 4 percent slopes (DaB).—This soil is in areas that are generally long and narrow, but a few areas are delta-shaped and lie at the mouth of waterways.

This soil is adjacent to the Barnes and Langhei soils on the upper slopes and to the Svea, Parnell, Flom, or Vallers soils on the lower slopes. Where this soil borders outwash areas, it joins the Renshaw soils on the lower side. Small areas of the Svea, Barnes, Parnell, and Flom soils are included with this soil in mapping.

This soil is well suited to all crops. However, since the soil areas are generally small, they are generally farmed like the adjacent soils. Water erosion can be a hazard on the steeper, longer slopes. (Capability unit I–1; windbreak suitability group 1)

Dickinson Series

The Dickinson series consists of deep, somewhat excessively drained, loamy outwash soils that are underlain by fine sand and sand. These nearly level to sloping soils are in the eastern part of the county.

In a representative profile, the surface layer is slightly acid, black sandy loam about 9 inches thick. The subsoil is slightly acid, very dark grayish-brown and dark-brown sandy loam that grades to brown loamy sand in the lower few inches. It is about 13 inches thick. The underlying material is slightly acid, brown and yellowish-brown sand that grades to light olive-brown fine sand in the lower part.

The organic-matter content is high, but the available water capacity and natural fertility are low. Permeability is moderately rapid in the surface layer and subsoil and is rapid in the underlying material. Droughtiness and low fertility are the major concerns in managing these soils. The soils are moderately well suited to crops if rainfall is adequate and good soil management is practiced.

Following is a representative profile of a Dickinson sandy loam having a slope of 1 percent, located 80 feet north and 500 feet east of the SW. corner of the SE¼ sec. 27, T. 126 N., R. 36 W.

Ap—0 to 9 inches, black (10YR 2/1) sandy loam; weak, fine, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

B1—9 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

B2—16 to 20 inches, dark-brown (10YR 3/3) sandy loam; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

B3—20 to 22 inches, brown (10YR 4/3) loamy sand; single grain; loose; slightly acid; gradual, wavy boundary.

C1—22 to 28 inches, brown (10YR 4/3) sand; single grain; loose; slightly acid; gradual, wavy boundary.

C2—28 to 42 inches, yellowish-brown (10YR 5/4) sand; single grain; loose; slightly acid; gradual, wavy boundary.

C3—42 to 60 inches, light olive-brown (2.5Y 5/4) fine sand; few, fine, faint, olive-yellow mottles; single grain; loose; slightly acid.

The A horizon ranges from 6 to 12 inches in thickness. The B horizon is 6 to 15 inches thick and is very dark gray to dark brown. The C horizon is fine sand and sand.

The Dickinson soils have coarser textured A and B horizons and a slightly finer textured C horizon than the Estherville soils. Typically, they are coarser textured throughout than the Clarion soils.

Dickinson sandy loam, 0 to 2 percent slopes (DcA).—This nearly level soil is in the eastern part of the county. It is in areas that are irregular in shape but often are somewhat elongated. Most areas lie parallel to drainageways. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas that have loamy fine sand or loamy sand B horizon, and small areas of Estherville loam. Also included are small wind-eroded areas where the surface layer is sandy and is brownish colored. In a few places small areas of moderately well drained soils occupy the lower slopes.

All the crops common in the county are grown on this soil. Crops that mature early are better suited to this soil because they make good use of the limited amount of available moisture. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to control erosion and maintain a high level of organic matter and plant nutrients. (Capability unit IIIs–2; windbreak suitability group 6)

Dickinson sandy loam, 2 to 6 percent slopes (DcB).—This gently sloping soil is in the eastern part of the county. It occupies areas that are irregular in shape and often slope toward drainageways or potholes. Slopes are uniform and generally range from 75 to 150 feet in length.

This soil has a profile similar to that described as typical for the series. Included with this soil in mapping are small areas having a loamy sand subsoil and a few small areas of Estherville loam. In some places the slopes are less than 2 percent or greater than 6 percent. About one-third of the areas mapped as this soil are moderately eroded, and nearly two-thirds of the original surface layer has been removed. These eroded areas have the steeper slopes, and the surface layer there is brownish in color.

All the crops common in the county are grown on this soil. Crops that mature early are better suited to this soil because they make good use of the limited amount of available moisture. Soil blowing is a hazard in fields left unprotected during winter and spring. Water erosion is a hazard on the longer and steeper slopes. Management is needed to control erosion and maintain a high level of organic matter and plant nutrients. (Capability unit IIIs–2; windbreak suitability group 6)

Doland Series

The Doland series consists of deep, well-drained soils that have developed in shallow, windblown silty material and in the underlying calcareous loam glacial till. These nearly level to gently sloping soils occur throughout the county but are mainly in Walden and Blue Mounds Townships.

In a representative profile, the surface layer is neutral, black silt loam about 8 inches thick. The subsoil is neutral, mainly brown silt loam in the upper 14 inches. The lower 2 inches is brown loam. The upper part of the underlying material is strongly calcareous, grayish-brown loam. The lower part is calcareous, light olive-brown loam.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate.

Most of the acreage of these soils is under cultivation. The soils are well suited to crops if they are properly managed.

Following is a representative profile of a Doland silt loam having a slope of 1 percent, located 170 feet west of field approach in the NE¼SE¼ sec. 18, T. 124 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B1—8 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, very fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—10 to 22 inches, brown (10YR 4/3) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

IIB3—22 to 24 inches, brown (10YR 4/3) loam, dark grayish brown (10YR 4/2) when crushed; weak, fine, subangular blocky structure; friable; neutral; gradual, irregular boundary.

IIC1ca—24 to 32 inches, grayish-brown (2.5Y 5/2) loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

IIC2—32 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, faint, grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The thickness of the silt cap ranges from 18 to 40 inches, but generally the silt cap is about 24 inches thick. Pebbles and small stones generally are on the soil surface. The Ap horizon is 7 to 10 inches thick. Free lime is leached to a depth of 16 to 28 inches and normally occurs with the glacial till. In some places the texture at the contact between the silt and till is light loam or sandy loam.

The Doland soils have a silt loam solum, whereas the Barnes solum is loam. The Doland soils have a thinner A horizon than the Tara soils.

Doland silt loam, 0 to 2 percent slopes (DlA).—This nearly level soil occurs throughout the county but mainly in Walden and Blue Mounds Townships. It occupies areas that are broad, irregular, and slightly elevated. This soil has the profile described as representative for the series.

Included with this soil in mapping are small areas of the Tara and McIntosh soils. In some places the silt cap is thin or the pebbly glacial till is exposed. In other places, however, the silt cap ranges from 40 to 60 inches in thickness. In the northeastern part of Westport Township, this Doland soil is leached of lime to below a depth of 24 inches and lacks the definite zone of lime accumulation that is normal in this soil.

This soil is farmed mostly to corn and soybeans. It is moderately well suited to well suited to crops. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control erosion and maintain a high level of organic matter and plant nutrients. (Capability unit I–1; windbreak suitability group 1)

Doland silt loam, 2 to 6 percent slopes (DlB).—This gently sloping soil occurs throughout the county but mainly in Walden and Blue Mounds Townships. Its areas are broad and irregular in shape. Slopes are generally smooth and range from 100 to 150 feet in length.

On the upper part of the slopes, much of the original surface layer of this soil has been removed by erosion, and in these places the plow layer has a brownish color because some of the brown subsoil has been mixed with the remaining surface layer. On the lower slopes, the soil is generally not eroded, and where soil material has accumulated, the present surface layer is thicker than normal. In some places this soil is moderately eroded and has lost more than one-third of its original surface layer.

This soil occurs closely with the Barnes and Langhei soils. Small areas of these soils are included with this soil in mapping. The Barnes and Langhei soils occupy the higher positions in the landscape and occur as pebbly spots that are generally calcareous. In some places the silt cap is greater than 40 inches thick. In the northeastern part of Westport Township, the free lime has been leached to a depth of about 24 inches and the soil lacks a definite zone of lime accumulation.

This soil is farmed generally to corn, soybeans, and small grains. It is moderately well suited to well suited to crops. Water erosion is a hazard on the longer slopes. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to control erosion and maintain a high level of organic matter and plant nutrients. (Capability unit IIe–1; windbreak suitability group 1)

Estelline Series

The Estelline series consists of well-drained soils that are moderately deep over sand and gravel. These soils have developed in sorted silts overlying calcareous sand and gravel. These nearly level to gently sloping soils are in the western part of the county, mainly in Walden Township.

In a representative profile, the surface layer is neutral silt loam that is about 14 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is about 15 inches thick. It is neutral, very dark brown and dark grayish-brown silt loam that grades to brown loam in the lower part. The underlying material is neutral, brown loam in the upper part and calcareous, light olive-brown sand and gravel in the lower part.

The organic-matter content is high. Natural fertility is moderate because the zone of root development is restricted. The available water capacity is moderate. Permeability is moderate in the silty material and very rapid in the sand and gravel.

Most areas of these soils are farmed intensively and are moderately well suited to crops. Soil blowing is a hazard in unprotected fields during spring and winter. Droughtiness is a moderate hazard.

Following is a representative profile of Estelline silt loam, located in a level cultivated field, 150 feet east and 30 feet north of the center of sec. 32, T. 124 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, clear boundary.

A12—8 to 14 inches, very dark gray (10YR 3/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B1—14 to 17 inches, very dark brown (10YR 2/2) silt loam, very dark grayish brown (10YR 3/2) when crushed; weak, fine, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

B12—17 to 26 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 4/3) when crushed; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

B22—26 to 29 inches, brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1—29 to 32 inches, brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC2—32 to 60 inches, light olive-brown (2.5Y 5/4) sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 10 to 16 inches in thickness. The B horizon is 12 to 18 inches thick and is silt loam or loam. Depth to sand and gravel ranges from 24 to 36 inches.

The Estelline soils have a more gravelly C horizon than the Flandreau or Doland soils.

Estelline silt loam, 0 to 3 percent slopes (Es).—This soil occurs in outwash areas and is closely associated with the Renshaw, Fordville, and Flandreau soils. Small areas of these soils are included with this Estelline soil in mapping. In places on the upper part of the slopes, the surface layer is moderately eroded and brownish colored. Here, the depth to the underlying sand and gravel is commonly less than 24 inches. On the lower slopes, where soil material has accumulated, the surface layer is thicker than normal. In some places small areas of this soil are moderately well drained.

All the crops common in the county are grown on this soil. It is moderately well suited to crops. Yields are much affected by the amount of rainfall. This soil is well suited to field and vegetable crops grown under irrigation. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control soil erosion and maintain a high level of organic matter and plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIs–1; windbreak suitability group 2)

Estelline Series, Moderately Well Drained Variant

The Estelline series, moderately well drained variant, consists of moderately well drained soils that are moderately deep over sand and gravel. These soils have developed in sorted silts overlying calcareous sand and gravel. They are nearly level or in slightly depressed areas and occur in the western part of the county.

In a representative profile, the surface layer is neutral silt loam about 14 inches thick. It is black in the upper part and grades to very dark brown in the lower part. The subsoil is about 18 inches thick. It is neutral silt loam, mainly dark grayish brown in the upper part and olive brown in the lower part. The underlying material is calcareous, light olive-brown sand and fine gravel.

The organic-matter content is high. Natural fertility is moderate because the zone of the root development is restricted. The available water capacity is moderate. Permeability is moderate in the silty material and very rapid in the sand and gravel.

Most areas of these soils are under cultivation and are moderately well suited to crops. Soil blowing is a hazard in unprotected fields during winter and spring.

Following is a representative profile of Estelline silt loam, moderately well drained variant, having a slope of 1 percent, located 200 feet west and 150 feet south of the NE. corner of the SW¼ sec. 30, T. 124 N., R. 40 W.

Ap—0 to 9 inches, black (10YR 2/1) silt loam; cloddy, breaking to moderate, fine, subangular blocky structure; friable; numerous wormcasts; neutral; abrupt, smooth boundary.

A12—9 to 14 inches, very dark brown (10YR 2/2) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B1—14 to 17 inches, very dark grayish-brown (10YR 3/2) silt loam, dark brown (10YR 3/3) when crushed; coarse, platy structure breaking to weak, fine, subangular blocky; friable; neutral; tongues of material from the Ap horizon extend to a depth of 17 inches; gradual, wavy boundary.

B2—17 to 23 inches, dark grayish-brown (10YR 4/2) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B31—23 to 30 inches, olive-brown (2.5Y 4/4) silt loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; thin, patchy clay films; neutral; gradual, wavy boundary.

B32—30 to 32 inches, olive-brown (2.5Y 4/4) loam; few, fine, distinct, light olive-brown mottles; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC—32 to 60 inches, light olive-brown (2.5Y 5/4) sand and fine gravel; few, fine, faint, light olive-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 12 to 18 inches in thickness. The B horizon ranges from 8 to 20 inches in thickness. The solum ranges from 22 to 34 inches in thickness but generally is about 30 inches thick. Depth to free lime is 22 to 34 inches.

The Estelline soils, moderately well drained variant, have a thicker solum than the Osakis soils. They have a finer textured solum than the Fordville soils. They have a more gravelly C horizon than the Tara soils.

Estelline silt loam, moderately well drained variant (0 to 2 percent slopes) (Et).—This level to slightly depressional soil is in the outwash areas of the western part of the county, particularly in Walden Township.

This soil occurs closely with the Renshaw, Fordville, Flandreau, and well-drained Estelline soils. Small areas of these soils are included with this soil in mapping. This Estelline variant has a thicker surface layer and more olive colors in the subsoil than the included soils.

This soil is farmed mostly to corn, soybeans, and small grains. It is moderately well suited to these crops. It is also well suited to irrigated field and vegetable crops. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control soil blowing and maintain good soil tilth. Applications of nitrogen and phosphorus are also needed. (Capability unit IIs–1; windbreak suitability group 8)

Estherville Series

The Estherville series consists of somewhat excessively drained, loamy soils that are shallow over calcareous sand and gravel. These soils have developed in loamy material and in the underlying sand. These level to rolling soils are in the outwash area in the eastern third of the county.

In a representative profile, the surface layer is slightly acid, black loam about 6 inches thick. The subsoil is slightly acid, very dark grayish-brown and dark-brown loam in the upper 12 inches, and neutral, brown coarse sand in the lower 3 inches. The upper part of the underlying material is calcareous, brown coarse sand. The lower part is yellowish-brown sand and gravel.

The organic-matter content is medium to high. Natural fertility is low to medium because the zone of root development is limited. The available water capacity is low. Permeability is moderate in the surface layer and subsoil, and rapid in the underlying sand and gravel. Droughtiness and low fertility are major limitations in using these soils; however, with adequate rainfall, they are moderately well suited to crops. These soils are a good source of sand and gravel for road construction.

Following is a representative profile of an Estherville loam having a slope of 1 percent, located 65 feet east of field approach on the west side of the SW¼NW¼ sec. 12, T. 125 N., R. 37 W.

Ap—0 to 6 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

B1—6 to 10 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

B2—10 to 18 inches, dark-brown (10YR 3/3) loam; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.

IIB3—18 to 21 inches, brown (10YR 4/3) coarse sand; single grain; loose; neutral; gradual, wavy boundary.

IIC1—21 to 25 inches, brown (10YR 4/3) coarse sand; single grain; loose; calcareous; gradual, wavy boundary.

IIC2—25 to 60 inches, yellowish-brown (10YR 5/4) sand and gravel; loose; calcareous.

The A horizon ranges from 5 to 12 inches in thickness. It is loam in most places, but sandy loam in small areas. The B horizon is 6 to 16 inches thick; the B1 and B2 horizons are loam or sandy loam. The thickness of the solum ranges from 12 to 22 inches. Depth to free lime is 18 to 30 inches.

The Estherville soils are underlain by sand and gravel but the Dickinson soils are underlain by fine sand. The Estherville soils have a thicker solum than the Salida soils; they are shallower to gravel than the Wadena soils; and they are more acid than the Renshaw soils.

Estherville loam, 0 to 2 percent slopes (EvA).—This soil is in the outwash area of the eastern third of the county. Areas of this soil are broad and irregular in shape. This soil has the profile described as representative for the series.

This Estherville loam occurs near Wadena and Salida soils. It lies above the lower, slightly depressed Wadena soils and below the Salida soils, which occupy the highest positions on the slopes. Small areas of the Wadena and Salida soils are included in areas mapped as this soil.

All crops common in the county are grown on this soil, but they are poorly suited to it. Crops that mature early are better suited than other crops because they make good use of the limited amount of available moisture. Soil blowing is a hazard in fields left unprotected during winter and spring. This soil is suitable for irrigated field and vegetable crops. Management is needed to control erosion, conserve moisture, and maintain a high level of plant nutrients. (Capability unit IIIs–1; windbreak suitability group 6)

Estherville loam, 2 to 6 percent slopes (EvB).—This gently sloping and undulating soil is in the outwash area of the eastern third of the county. Soil areas are broad and irregular in shape. Slopes are short and range from 50 to 200 feet in length.

This soil has a profile similar to that described as representative for the series but commonly is moderately eroded on the upper part of the slopes. Some of the surface layer has been mixed with the subsoil. Here, the surface layer is thin and brownish colored. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

This soil occurs near the Salida and Wadena soils, and small areas of these soils are included in areas mapped as this soil.

All the common crops are grown on this soil. Crops that mature early are better suited than other crops because of the limited amount of available moisture. Long dry periods reduce crop growth. This soil is suitable for irrigated field and vegetable crops. Management is needed to control erosion, conserve moisture, and maintain a high level of plant nutrients. (Capability unit IIIe–3; windbreak suitability group 6)

Estherville loam, 6 to 12 percent slopes, eroded (EvC2).—This sloping to rolling soil is in the outwash area of the eastern third of the county, mainly in Glenwood Township. Areas of this soil are generally elongated, irregular, and lie parallel to waterways or marshes. Slopes are normally smooth and range from 75 to 250 feet in length.

Most acreage of this soil is moderately eroded. About two-thirds of the original surface layer has been removed, and some of the subsoil has been mixed with the remaining surface layer to form a brownish plow layer. At the base of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

This soil occurs near the Salida soils and in places includes small areas of them. The Salida soils are on the higher slopes. Also included with this soil in mapping are small areas in which the combined thickness of the surface layer and subsoil is greater than 24 inches.

This soil is farmed mostly to corn, soybeans, and small grains. Droughtiness is a serious limitation, and water erosion is a moderate hazard. Management is needed to control erosion, conserve moisture, and maintain a high level of plant nutrients and organic matter. (Capability unit IVe–2; windbreak suitability group 6)

Estherville loam, thick solum, 0 to 2 percent slopes (EwA).—This level to slightly depressional soil is in the eastern third of the county. It occurs near the normal Estherville loam, but it occupies slightly lower areas in the landscape, and its surface layer and subsoil have a combined thickness of 20 to 26 inches. Included with this soil in mapping are small areas of normal Estherville loams and of Wadena loam. The Wadena loam is in the slightly depressional areas.

All of the common crops are grown on this soil. It is well suited to irrigated field and vegetable crops. Soil blowing is a hazard in fields left unprotected during winter and spring. Long dry periods reduce crop growth. Management is needed to control erosion and maintain a high level of plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIs–1; windbreak suitability group 2)

Estherville loam, thick solum, 2 to 6 percent slopes (EwB).—This soil is in the outwash areas in the eastern third of the county. It occurs near normal Estherville loams, and small areas of those soils were included in mapping. Unlike normal Estherville loams, this soil has a surface layer and subsoil having a total thickness of 20 to 26 inches. In most places where this soil occupies the upper part of slopes, it is moderately eroded and has a thin, very dark brown surface layer. On the lower part of slopes, where soil material has been washed down, the surface layer is thicker than normal.

All of the common crops are grown on this soil. Soil blowing is a hazard in fields left bare during winter and spring. Water erosion is a hazard on the steeper slopes. Crops do not grow well during periods of extended drought. This soil is well suited to irrigated field and vegetable crops. Management is needed to control soil erosion and maintain high levels of organic matter and plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIe–3; windbreak suitability group 2)

Flandreau Series

The Flandreau series consists of well-drained soils that are moderately deep over sand. These soils have developed in sorted silt overlying calcareous sands. These level to gently sloping soils are in the western part of the county.

In a representative profile, the surface layer is neutral silt loam about 10 inches thick. The upper part is black and the lower part grades to very dark brown. The subsoil is neutral very dark grayish-brown to dark yellowish-brown silt loam about 15 inches thick. The underlying material is calcareous, brown loamy fine sand in the upper part and light brownish-gray sand in the lower part.

The organic-matter content is high. Natural fertility is moderate because the zone of root development is limited. The available water capacity is moderate. Permeability is moderate in the surface and subsoil layers and rapid in the underlying material. Most areas of these soils are under cultivation. Soil blowing and droughtiness are major limitations. If rainfall is adequate, these soils are moderately well suited to crops, provided good soil management is practiced.

Following is a representative profile of Flandreau silt loam, on a slope of 3 percent, located 50 feet east of the NW. corner of the SW¼ sec. 35, T. 124 N., R. 40 W.

Ap—0 to 6 inches, black (10YR 2/1) silt loam; cloddy; friable; neutral; abrupt, smooth boundary.

A12—6 to 10 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, angular blocky structure; friable; neutral; clear, wavy boundary.

B1—10 to 14 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, very fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B21—14 to 19 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, coarse, prismatic structure breaking to weak, very fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B22—19 to 25 inches, dark yellowish-brown (10YR 4/6) silt loam; weak, very fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC1—25 to 40 inches, brown (10YR 5/3) loamy fine sand; single grain; loose; calcareous; gradual, smooth boundary.

IIC2—40 to 60 inches, light brownish-gray (10YR 6/2) sand; single grain; loose; calcareous.

The A horizon ranges from 7 to 12 inches in thickness. The horizon generally is silt loam or loam that is high in very fine sands. The B horizon is 8 to 18 inches thick. Free lime is leached to the C horizon. Depth from the soil surface to the underlying sand is 24 to 40 inches. The underlying sand is fine but contains some medium-size grains.

The Flandreau soils have a less gravelly C horizon than the Estelline soils, and a more sandy C horizon than the Doland soils.

Flandreau silt loam, 0 to 2 percent slopes (FlA).—This soil is in the level to nearly level areas throughout the western part of the county, mainly south of Lake Emily.

This soil has the profile described as representative for the series. It occurs near the Maddock, Renshaw, and Estelline soils, and small areas of these soils are included with this soil in mapping. Where this soil is in the uplands, small areas of the Barnes or Sverdrup soils are mapped as this soil.

This soil is farmed intensively to corn, soybeans, and small grains. Soil blowing is a hazard in fields left unprotected during winter and spring. Droughtiness is a hazard during long dry periods. Management is needed to control soil blowing and maintain high levels of organic matter and plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIs–1; windbreak suitability group 2)

Flandreau silt loam, 2 to 6 percent slopes (FlB).—This soil is mainly in the glacial outwash areas in the western part of the county. It has the profile described as representative for the series.

This soil occurs near the Maddock, Renshaw, Sverdrup, and Barnes soils. Small areas of these soils were included with this soil in mapping. In places small areas of soil with a calcareous surface layer are also included. In some places where this Flandreau soil occupies the higher slopes, it is moderately eroded and has a brownish-colored surface layer. On the lower slopes, where soil material has been washed down, the surface layer is thicker than normal.

All the common crops are grown on this soil. Soil blowing is a hazard in fields left unprotected during winter and spring. Droughtiness is a moderate hazard. Water erosion is a hazard on the steeper slopes. Management is needed to control erosion and maintain high levels of organic matter and plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIe-3; windbreak suitability group 2)

Flom Series

The Flom series consists of poorly drained soils that have developed in medium-textured or moderately fine textured glacial material. These soils occur in the broad, slightly depressed, level areas in the ground moraine.

In a representative profile, the surface layer is neutral, black silty clay loam in the upper 15 inches, and it grades to a very dark gray loam in the lower 4 inches. The subsoil is neutral, very dark grayish-brown loam about 3 inches thick. The underlying material is calcareous loam with mainly yellowish-brown mottles. It is grayish brown in the upper part and grades to light olive brown in the lower part.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderately slow, and these soils are generally wet. Early in the year the water table is at a depth of about 2 feet, and this keeps the soil temperature low and restricts the zone of root development. These soils are farmed intensively to corn and soybeans. If they are adequately drained, these soils are well suited to crops.

Following is a representaive profile of a Flom silty clay loam, located in a level, cultivated field, 180 feet east and 60 feet south of the NW. corner of sec. 9, T. 124 N., R. 40 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam; moderate, fine, subangular blocky structure; friable; numerous worm casts; neutral; abrupt, smooth boundary.

A12—6 to 15 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A13g—15 to 19 inches, very dark gray (10YR 3/1) loam; few, fine, faint, dark yellowish-brown mottles; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—19 to 22 inches, very dark grayish-brown (2.5Y 3/2) loam; common, fine, distinct, dark yellowish-brown mottles; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1—22 to 29 inches, grayish-brown (2.5Y 5/2) loam; many, medium, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2ca—29 to 36 inches, grayish-brown (2.5Y 5/2) loam; common, fine, prominent, light olive-brown and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2—36 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, medium, distinct, light brownish-gray, grayish-brown, and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 14 to 24 inches in thickness and is silt loam, loam, and silty clay loam in texture. Depth to free lime is 18 to 28 inches.

The Flom soils have a neutral surface layer, whereas the Vallers soils have a calcareous surface layer. They lack the textural B horizon of the Parnell soils, and they differ from the Perella soils in that they have developed in glacial till.

In Pope County the Flom soils were mapped only in an undifferentiated unit with the Parnell soils. For a description of this unit, see the Parnell series.

Fordville Series

The Fordville series consists of well-drained soils that are moderately deep over sand and gravel. These soils have developed in loam-textured outwash overlying calcareous sand and gravel. These level and gently sloping soils are in the western two-thirds of the country.

In a representative profile, the surface layer is neutral loam about 15 inches thick. It is black in the upper 8 inches and grades to very dark grayish brown in the lower 7 inches. The subsoil is neutral, dark grayish-brown loam in the upper part. The middle part is calcareous, dark grayish-brown sandy loam. The lower part is calcareous, brown sand. The underlying material below a depth of about 32 inches is calcareous to strongly calcareous, brown sand and gravel.

The organic-matter content is high, but natural fertility is medium because the zone of root development is limited. The available water capacity is low to moderate. Permeability is moderate in the surface and subsoil layers, and very rapid in the underlying material. These soils are slightly droughty. If rainfall is adequate, they are well suited to crops, provided good soil management is practiced. These soils are a good source of sand and gravel for road construction.

Following is a representative profile of a Fordville loam, located 200 feet west and 10 feet south of field approach in the NW¼NE¼SE¼ sec. 4, T. 123 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy, breaking to weak, fine, subangular structure; friable; neutral; abrupt, smooth boundary.

A3—8 to 15 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—15 to 25 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

B31—25 to 27 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

IIB32—27 to 32 inches, brown (10YR 4/3) sand; single grain; loose; calcareous; gradual, wavy boundary.

IIC1—32 to 34 inches, brown (10YR 5/3) sand; single grain; loose; calcareous; gradual, wavy boundary.

IIC2—34 to 60 inches, brown (10YR 5/3) sand and gravel; single grain; loose; friable; strongly calcareous.

The A horizon is loam or silt loam, and it ranges from 6 to 16 inches in thickness. The B horizon is 10 to 22 inches thick. Depth to free lime ranges from 15 to 28 inches, and generally is at the upper part of the C horizon. Depth to sand and gravel is from 24 to 40 inches.

The Fordville soils have a thicker solum than the Renshaw soils. They have a slightly coarser textured solum than the Estelline soils.

Fordville loam, 0 to 2 percent slopes (FoA).—This soil is in the western two-thirds of the county, mainly on the outwash plain of the Chippewa River in Hoff and Walden Townships.

This soil has the profile described as representative for the series. Included with this soil in mapping are small areas of Renshaw loam, Estelline silt loam, and Sverdrup sandy loam. In places some slightly elevated areas of this Fordville soil are moderately eroded. In the slightly depressional areas, however, the surface layer is thicker than normal.

All crops common in the county are grown on this soil. It is moderately well suited to well suited to crops, depending on the amount of rainfall received. This soil is well suited to irrigated field or vegetable crops. Soil blowing is a hazard in fields left bare during winter and spring. Droughtiness is a limitation on this soil. Management is needed to control soil erosion and maintain high levels of organic matter and plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIs–1; windbreak suitability group 2)

Fordville loam, 2 to 6 percent slopes (FoB).—This soil is in gently sloping areas throughout the western two-thirds of the county. It is mostly adjacent to streams and waterways in the glaciated uplands, where it is near the Barnes and Sverdrup soils.

This soil has a profile similar to that described as representative for the series. Included with this soil in mapping are small areas of Renshaw loam, Sverdrup sandy loam, Estelline silt loam, and Flandreau silt loam. In places small areas of this Fordville soil are moderately eroded. On the lower part of the slopes and in the slight depressions the surface layer is thicker than normal.

All the common crops are grown on this soil. It is moderately well suited to crops. Long dry periods reduce crop growth. Soil blowing is a hazard in fields left unprotected during winter and spring. Water erosion is a hazard on the steeper slopes. Management is needed to control soil erosion and maintain high levels of organic matter and plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIe–3; windbreak suitability group 2)

Forman Series

The Forman series consists of deep, well-drained soils that have developed in calcareous loam and clay loam glacial till. These gently sloping to sloping soils are mainly in Lake Reno Township, with some small areas also in Langhei Township.

In a representative profile, the surface layer is neutral, black clay loam about 7 inches thick. The subsoil is neutral clay loam about 18 inches thick that is very dark gray in the upper part; dark grayish brown in the middle part, and brown in the lower part. The underlying material is calcareous to strongly calcareous, yellowish-brown loam in the upper part, light olive-brown loam in the middle part, and grayish-brown loam in the lower part.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderately slow. Erosion control and fertility management are the major concerns in using these soils. The Forman soils are all under cultivation. Water erosion is a hazard on the slopes. These soils are well suited for growing crops if rainfall is adequate and proper management is practiced.

Following is a representative profile of a Forman clay loam in a cultivated field, located 900 feet north, on the road 125 feet east of the SW. corner of the SE¼SW¼ sec. 6, T. 126 N., R. 38 W.

Ap—0 to 7 inches, black (10YR 2/1) clay loam; cloddy, breaking to weak, fine, subangular blocky; friable; neutral; abrupt, smooth boundary.

B1—7 to 12 inches, very dark gray (10YR 3/1) clay loam, with very dark grayish-brown interior color; strong, medium, subangular blocky structure; friable; clay films on vertical ped faces; neutral; gradual, wavy boundary.

B21—12 to 18 inches, dark grayish-brown (10YR 4/2) clay loam; strong, medium, subangular blocky structure; friable; clay films on vertical ped faces; tongues of black extend to a depth of 20 inches; neutral; gradual, wavy boundary.

B22—18 to 21 inches, dark grayish-brown (10YR 4/2) clay loam; weak, medium, subangular blocky structure; friable; patchy clay films on ped faces; neutral; gradual, wavy boundary.

B23—21 to 25 inches, brown (10YR 4/3) clay loam; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1—25 to 28 inches, yellowish-brown (10YR 5/4) loam; massive; friable; calcareous; gradual, wavy boundary.

C2ca—28 to 34 inches, light olive-brown (2.5Y 5/4) loam; many, fine, faint, olive-brown mottles; massive; friable; strongly calcareous; gradual, wavy boundary.

C3—34 to 60 inches, grayish-brown (2.5Y 5/2) loam; many, medium, prominent, yellowish-brown mottles; massive; friable; calcareous.

The A horizon ranges from 6 to 10 inches in thickness and it is loam or clay loam in texture. The B horizon is 12 to 23 inches thick. Black clay films commonly coat the peds in the upper part. Clay films range from patchy to continuous. The C horizon is calcareous loam or clay loam. Lime is leached to a depth of 20 to 30 inches. A layer of lime accumulation 5 to 10 inches thick occurs below the B horizon. Pebbles and stones are common throughout the profile. In some places, pebble bands are in the soil profile.

The Forman soils have a finer textured and thicker B horizon than the Barnes soils. They have a thicker solum than the Langhei soils. They do not have the bleached soil grains in the A horizon and the organic staining in the lower part of the B horizon found in the Waukon soils.

Forman clay loam, 2 to 6 percent slopes, eroded (FrB2).—This gently sloping soil is mainly in Reno Township, west and south of Lake Reno. Slopes are uniform and range from 100 to 300 feet in length. Soil areas are irregular in shape.

This soil has the profile described as representative for the series. On the upper part of the slopes the plow layer has a brownish color because some of the subsoil has been mixed with the surface layer. On the lower slopes, where soil material has accumulated, the surface layer is thicker than normal. Included with this soil in mapping are small areas of Barnes loam and Nutley silty clay loam. The Barnes soils commonly occur in the same areas as this soil, but the Nutley soils are in the slight depressions.

Corn, soybeans, small grains, and alfalfa are the main crops grown on this soil. Water erosion is a hazard on some slopes. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control erosion, keep good soil tilth, and provide a high level of fertility. (Capability unit IIe–1; windbreak suitability group 1)

Forman clay loam, 6 to 12 percent slopes, eroded (FrC2).—This sloping soil is mainly in Reno Township, west and south of Lake Reno, and also in section 3 of Langhei Township. Slopes are choppy and range from 75 to 200 feet in length. Soil areas are irregular in shape.

Most areas of this soil have a thin very dark grayish-brown surface layer because some of the plow layer has been mixed with the subsoil. At the base of the slopes and in waterways, where soil material has accumulated, the surface layer of this soil is thicker than normal. Included with this soil in mapping are small areas of Barnes loam, Langhei loam, and Nutley silty clay loam. The Barnes and Langhei soils occur closely with this Forman soil, and the Nutley loam is in slightly lower areas.

All the crops common in the county are grown on these soils. Water erosion is a moderate hazard. Soil blowing is a hazard in unprotected fields during winter and spring. Soil management is needed to control erosion and to maintain high levels of organic matter and plant nutrients. (Capability unit IIIe–1; windbreak suitability group 1)

Glencoe Series

The Glencoe series consists of deep, very poorly drained soils that have developed in the potholes and sloughs of the glacial moraine in the eastern part of the county.

In a representative profile, the surface layer is neutral, black, nonsticky to slightly sticky silty clay loam to a depth of about 22 inches. Below this it is neutral, slightly sticky, very dark gray loam and clay loam to a depth of about 60 inches.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderately slow. The water table is generally at or near the surface, and this limits the zone of root development. Wetness is a serious hazard. These soils cannot be farmed unless they are adequately drained. Areas of these soils are well suited for use as wildlife habitat if they are not drained.

Following is a representative profile of Glencoe silty clay loam, located in the NE. corner of the SE¼SE¼ sec. 26, T. 126 N., R. 36 W.

A11—0 to 8 inches, black (N 2/0) silty clay loam; massive; nonsticky; neutral; gradual, wavy boundary.

A12—8 to 16 inches, black (N 2/0) silty clay loam; massive; slightly sticky; neutral; gradual, wavy boundary.

A13g—16 to 22 inches, black (N 2/0) loam; strong, fine, subangular blocky structure; slightly sticky; neutral; gradual, wavy boundary.

A14g—22 to 30 inches, very dark gray (5Y 3/1) loam; weak, fine, subangular blocky structure; slightly sticky; neutral; gradual, wavy boundary.

A15g—30 to 60 inches, very dark gray (5Y 3/1) clay loam; massive; slightly sticky; neutral; gradual, wavy boundary.

The dark-colored A horizon ranges from 20 to 40 inches in thickness. In places a thin layer of muck is at the surface. The upper part of the soil profile includes silty clay loam and loam, and below a depth of about 20 inches, it is loam or clay loam.

The Glencoe soils generally are neutral throughout the profile, whereas the Canisteo soils are calcareous. They have a thicker A horizon than the Webster soils.

Glencoe silty clay loam (0 to 2 percent slopes) (Gn).—This soil is in the depressions and potholes of the glaciated areas in the eastern one-third of the county. It is flooded in spring, and generally it is flooded throughout the year.

Included with this soil in mapping are small areas of the Webster, Canisteo, and Nicollet soils. In places a thin layer of muck is on the surface.

If undrained, this soil is covered with reeds, sedges, rushes, and, in some places, stunted trees or shrubs. Areas of Marsh are shown on the soil map by wet symbols. These soil areas are well suited for use as wildlife habitat.

If drained, this soil is used as hayland, pasture, or cropland, depending upon the type of drainage used. Shallow ditches remove enough surface water so that these areas are suited to hay or pasture. Deep ditches drain surface water adequately to grow crops; however, wetness remains a hazard. If adequately drained, this soil is suited to all crops common in the county. Silage corn is well suited to this soil. Small grains, however, tend to lodge, and corn and soybeans generally do not reach maturity. (Capability unit IIIw–1; windbreak suitability group 3)

Hamar Series

The Hamar series consists of deep, poorly drained and very poorly drained soils that have developed in outwash sand. These soils are in the level areas in the southwestern part of the county.

In a representative profile, the surface layer is neutral sandy loam that is black in the upper 11 inches and very dark gray in the lower 4 inches. The subsoil is neutral, mottled, dark grayish-brown loamy sand about 9 inches thick. The underlying material is calcareous, mottled, grayish-brown sand.

The organic-matter content is high, but natural fertility is low because of the sandy subsoil. The available water capacity is low. Permeability is rapid. The water table is high, and this restricts the zone of root development. Nearly all acreage of these soils is farmed. Wetness is a hazard.

Following is a representative profile of a Hamar sandy loam in a cultivated level field, located 140 feet west and 90 feet north of the approach to the grove in the SW¼ SE¼ sec. 28, T. 123 N., R. 40 W.

Ap—0 to 6 inches, black (10YR 2/1) sandy loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—6 to 11 inches, black (10YR 2/1) sandy loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A3—11 to 15 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—15 to 24 inches, dark grayish-brown (2.5Y 4/2) loamy sand; few, fine, distinct, light olive-brown mottles; single grain; loose; few, black manganese concretions; neutral; gradual, wavy boundary.

C1—24 to 36 inches, grayish-brown (2.5Y 5/2) sand; common, fine, distinct, light olive-brown mottles; single grain; loose; few manganese concretions; calcareous; gradual, wavy boundary.

C2—36 to 60 inches, grayish-brown (2.5Y 5/2) sand; common, medium, distinct, light olive-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 12 to 20 inches in thickness. Depth to free lime is from 18 to 36 inches. The C horizon is generally medium sand but includes coarse sands.

The Hamar soils are free of lime in the A and B horizons, whereas the Arveson soils are calcareous throughout the profile. They have less olive color in the C horizon than the Hecla soils. They have a sandier upper C horizon than the Mayer soils.

Hamar sandy loam (0 to 2 percent slopes) (Hc).—This soil is in elongated areas that generally lie in a southeasterly direction.

This soil occurs closely with the Hecla, Clontarf, Arveson, and Hamar soils. Small areas of these soils are included in mapping with the Hamar soil. The Hecla and Clontarf soils occupy the slight rises in the soil area. Also included are about 85 acres of small wet depressions. In places a dark-colored buried surface layer is in the subsoil. In some places free lime is within 12 inches of the surface.

All the common crops are grown on this soil. Soil blowing is a hazard in unprotected fields during winter and spring. Fence-row drifts are common on most field boundaries. Early in summer the water table rises to within 2 feet of the surface, and this restricts the zone of root development. By late in summer the water table drops to a depth of about 4 feet, and some soil areas become droughty. Some undrained depressions contain surface water for most of the year and are under marsh vegetation. Management is needed to control erosion, provide drainage, and keep good soil tilth. (Capability unit IIIw-4; windbreak suitability group 7)

Hamerly Series

The Hamerly series consists of deep, moderately well drained soils that have developed in calcareous loam glacial till. These gently undulating to undulating soils are in the glacial till areas, mainly in the western part of the county.

In a representative profile, the surface layer is calcareous, very dark gray loam about 8 inches thick. The upper part of the underlying material is strongly calcareous, grayish-brown loam. The lower part is calcareous, light olive-brown to grayish-brown loam.

The organic-matter content and available water capacity are high, but natural fertility is moderate because the high lime content causes an imbalance of plant nutrients. Permeability is moderate. Most acreage of these soils is under cultivation. With proper management, these soils are moderately well suited to crops.

Following is a representative profile of a Hamerly loam having a slope of 2 percent, in a cultivated field, located 100 feet west and 60 feet north of the farm road in the SE¼SW¼NE¼ sec. 32, T. 124 N., R. 39 W.

A1—0 to 8 inches, very dark gray (10YR 3/1) loam; moderate, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

C1ca—8 to 15 inches, grayish-brown (2.5Y 5/2) loam; few, fine, faint, light olive-brown and light-gray mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—15 to 28 inches, light olive-brown (2.5Y 5/4) loam; few, fine, faint, grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C3—28 to 34 inches, light olive-brown (2.5Y 5/4) loam; moderate, fine, distinct, light brownish-gray mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C4—34 to 60 inches, grayish-brown (2.5Y 5/2) loam; moderate, fine, distinct, yellowish-brown mottles; weak, very fine, subangular blocky structure; calcareous.

The A horizon ranges from 6 to 12 inches in thickness and is loam, clay loam, or silt loam in texture. The C1ca horizon is 6 to 15 inches thick and is loam or clay loam in texture. Gypsum and manganese concretions occur in places in the underlying material.

The Hamerly soils have a thinner and less olive colored C horizon than the Langhei soils. They have a loam solum, whereas the McIntosh soils have a silt loam solum. Typically, they are calcareous throughout the profile, whereas the Svea soils are noncalcareous to a depth of 16 inches or more.

Hamerly loam, 0 to 3 percent slopes (Hd).—This soil occupies the slight rises in the glacial till areas. Soil areas vary in shape but generally are less than 10 acres in size and lie in a southeasterly direction.

This soil occurs near the Svea and Vallers soils and an undifferentiated unit of Parnell and Flom soils. Small areas of these included soils are in areas mapped as this soil. The Svea soils are in the level areas that surround the Hamerly areas. The Vallers and Parnell and Flom soils are in the lower, wetter areas. On the highest part of the slopes, the surface layer of this soil generally is moderately eroded. In those places the soil is light colored and highly calcareous.

All crops are grown on this soil; however, the high lime content causes an imbalance of available plant nutrients. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to control erosion and maintain high content of organic matter and plant nutrients. (Capability unit IIe-4; windbreak suitability group 5)

Hecla Series

The Hecla series consists of deep, moderately well drained soils that have developed in outwash sand. These nearly level to gently sloping soils occur in the southwestern part of Hoff Township.

In a representative profile, the surface layer is neutral, black loamy sand about 13 inches thick. The subsoil is neutral, very dark brown loamy sand about 6 inches thick. The upper part of the underlying material is neutral, mottled, olive-brown sand about 11 inches thick. The lower part to a depth of about 60 inches is calcareous, mottled, light olive-brown sand.

The organic-matter content is medium. Natural fertility is low. The available water capacity is very low. Permeability is rapid. Droughtiness, low fertility, and soil blowing are the major concerns in managing these soils. They are suited to grassland.

Following is a representative profile of Hecla loamy sand, 0 to 3 percent slopes, located 415 feet east and 25 feet north of the SW. corner of sec. 34, T. 123 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) loamy sand; cloddy, breaking to weak, medium, subangular blocky structure; friable; neutral; clear, smooth boundary.

A12—7 to 13 inches, black (10YR 2/1) loamy sand; weak, coarse, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—13 to 19 inches, very dark brown (10YR 3/2) loamy sand; few, fine, distinct, olive-brown mottles; single grain; loose; neutral; gradual, wavy boundary.

C1—19 to 30 inches, olive-brown (2.5Y 4/3) sand; medium, fine, distinct, brown and yellowish-brown mottles; single grain; loose; neutral; gradual, wavy boundary.

C2—30 to 36 inches, light olive-brown (2.5Y 5/3) sand; medium, fine, distinct, grayish-brown and dark yellowish-brown mottles; single grain; loose; calcareous; gradual, wavy boundary.

C3—36 to 60 inches, light olive-brown (2.5Y 5/4) sand; few, fine, faint, grayish-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 10 to 16 inches in thickness. Depth to free lime is from 24 to 40 inches. The C horizon is medium sand but includes some fine and coarse sand.

Typically, the Hecla soils have a coarser textured profile throughout than the Clontarf or Malachy soils. They have a more olive-colored C horizon than the Maddock soils.

Hecla loamy sand, 0 to 3 percent slopes (Hv).—This soil is in the slight rises in the nearly level areas. Soil areas generally are elongated and lie in a southeasterly direction.

This soil occurs closely with the Clontarf, Malachy, Maddock, Arveson, and Hamar soils. Small areas of these soils are included with this soil in mapping. Fence-row wind drifts are common at field boundaries. In some places the surface layer is buried in the soil profile. Also, in places small areas have been blown by the wind. Here, the soil areas are lighter in color than normal and have a sand texture.

All the common crops are grown on this soil, but crops that mature early make better use of the limited amount of available soil moisture. Droughtiness is a persistent hazard that threatens crop growth. Soil blowing is a common hazard in fields left unprotected during winter and spring. (Capability unit IVs–1; windbreak suitability group 6)

Lake Beaches

Lake beaches consists of areas along the edges of present or former lakes throughout the county.

Lake beaches, loamy (0 to 2 percent slopes) (Lb) consists generally of loam, but includes sandy loam areas. It occurs mainly along the edge of Lake Reno. Soil material along Lake Reno shows evidence of weak development. In places it has a very thin black loam surface layer that is underlain by olive-gray clay loam. In other areas in the county this soil may be just a deep, black loam or silt loam.

Drainage is very poor to poor, and the water table is near the surface. Free lime occurs throughout the soil profile. Natural fertility is moderate, and the available water capacity is high. This land generally is too wet for growing crops. Most acreage of this land is used as pasture or as wildlife habitat. (Capability unit VIw–1; windbreak suitability group 10)

Lake beaches, sandy (0 to 2 percent slopes) (La) consists mainly of mucky sand, sand, and loamy sand. In some places, particularly along the west side of Lake Reno and the north side of Lake Ellen, this land type has 3 to 6 percent slopes. These areas were formed by expanding ice that pushed the beach material into ridges and by a subsequent lowering of the level of the lake.

Drainage is very poor in the level areas where the water table is near the surface, and it is excessive on the slopes. Free lime occurs throughout the soil profile. Natural fertility and available water capacity are low.

This land is poorly suited to crops. Most acreage of this soil is used either as pasture or as wildlife habitat. (Capability unit VIw–1; windbreak suitability group 7)

Lamoure Series

The Lamoure series consists of deep, poorly drained soils that have developed in highly calcareous stream deposits. The soil areas are small and irregular in shape and are on the level bottom lands near rivers and other streams throughout the county.

In a representative profile, the surface layer is calcareous silt loam about 28 inches thick. It is mainly black but grades to very dark gray in the lower few inches. The upper part of the underlying material is calcareous, olive-gray loam with olive-brown and yellowish-brown mottles. Below a depth of 48 inches, it is sand.

The organic-matter content and available water capacity are high, but natural fertility is only moderate because of the high lime content. Permeability is moderate. The water table in this soil varies with the water level in the nearby streams. Early in summer the water table is at a depth of about 2 feet, but it drops to 4 or 5 feet late in summer. These soils generally are flooded in spring. They generally are used as pasture or as wildlife habitat. When soil areas are large enough to be cultivated, they are well suited to crops.

Following is a representative profile of a Lamoure silt loam in a nearly level, cultivated field, located 100 feet south of field approach in the NW¼NW¼ sec. 17, T. 125 N., R. 39 W.

A11—0 to 16 inches, black (10YR 2/1) silt loam; weak, fine, angular blocky structure; friable; calcareous; gradual, wavy boundary.

A12—16 to 20 inches, black (2.5Y 2/1) silt loam; weak, fine, angular blocky structure; friable; calcareous; gradual, wavy boundary.

A13g—20 to 28 inches, very dark gray (2.5Y 3/1) silt loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C1—28 to 48 inches, olive-gray (5Y 5/2) loam; common, fine, distinct, olive-brown and yellowish-brown mottles; massive; friable; calcareous; gradual, wavy boundary.

IIC2—48 to 60 inches, olive-gray (5Y 5/2) sand; common, fine, distinct, olive-brown and yellowish-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 16 to 30 inches in thickness. It is silt loam, light silty clay loam, or loam. Thin lenses of sand may be within the profile. Sand and gravel are common below a depth of 42 inches.

The Lamoure soils lack the strongly calcareous Cca horizon of the Colvin and Vallers soils, but they are calcareous throughout, whereas the Perella soils are noncalcareous to a depth of 18 inches or more.

Lamoure silt loam (0 to 2 percent slopes) (Lc).—This soil is in the flat areas near the rivers and streams, mainly the Chippewa, Little Chippewa, and East Branch of the Chippewa Rivers.

This soil has the profile described as representative for the series. Small areas of Lamoure silt loam, wet, that occupies the old stream channels within the Lamoure soil area are included with this soil in mapping. The Lamoure soil occupies 5 to 25 acre areas. Most soil areas are large enough or are close to better drained soils and are under cultivation. Smaller areas of this soil generally are used as woodland or pasture. If this soil is used to grow crops, surface drainage is needed in most areas.

All crops common in the county are grown on this soil. It is well suited to crops, but the high lime content causes an imbalance of plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed. (Capability unit IIw–2; windbreak suitability group 4)

Lamoure silt loam, wet (0 to 2 percent slopes) (Lh).—This soil is in the level to depressional areas on the bottom lands along the streams.

This soil has a profile similar to that described as representative for the series. It occurs closely with Lamoure silt loam and Alluvial land. Small areas of these soils are included with this soil in mapping. This soil is in the depressional areas of the old stream channels, and the normal Lamoure soil is in the level areas above it. In places a thin muck layer is on the soil surface.

This soil is well suited for use as wildlife habitat, but it is generally used as pasture. Wetness and flooding are serious limitations because these soil areas are difficult to drain. Management is needed to develop the areas for wildlife or to restrict grazing until late in summer. (Capability unit VIw–1; windbreak suitability group 10)

Lamoure complex (0 to 2 percent slopes) (Lk).—The level to slightly depressed soils that make up this complex are adjacent to the rivers and streams, mainly along the Chippewa, Little Chippewa, and East Branch of the Chippewa Rivers. Soil areas are irregular in shape and vary in size from 5 to 25 acres. Lamoure silt loam makes up about 60 percent of the soil area; Lamoure silt loam, wet, about 35 percent; and the remaining 5 percent is Alluvial land.

The Lamoure silt loam occupies the nearly level slopes, and the Lamoure silt loam, wet, is in the old channels that meander through the area. The Lamoure silt loam is generally flooded early in spring or after excessive rainfall. The Lamoure silt loam, wet, is flooded during most of the summer and after any slight rise in the nearby streams.

It is difficult to farm soils of this complex because the Lamoure silt loam, wet, is commonly flooded. About 40 percent of the acreage in this unit is being cultivated. They are poorly suited to moderately well suited to crops. The remaining 60 percent is used as pasture or woodland. The Lamoure silt loam, wet, is well suited to use as wildlife habitat. (Both Lamoure soils, capability unit IIw–2; Lamoure silt loam, windbreak suitability group 4; Lamoure silt loam, wet, windbreak suitability group 10)

Langhei Series

The Langhei series consist of deep, somewhat excessively drained soils that have developed in calcareous loam till. These undulating to very steep soils are in the western two-thirds of the county.

In a representative profile, the surface layer is calcareous very dark grayish-brown loam about 8 inches thick. The underlying material is light olive-brown loam. The upper 12 inches is strongly calcareous. Below this, to a depth of 60 inches, the material is calcareous.

Organic-matter content is low, available water capacity is high, and permeability is moderate. Natural fertility is low because of the high lime content. Erosion, low fertility, and droughtiness are the major limitations to use of these soils. Most areas of these soils are under cultivation, but they are poorly suited to crops. The steeper slopes are commonly used for grassland.

Following is a representative profile of Langhei loam having a slope of 5 percent, located 185 feet north and 50 feet west of field approach in the NE¼SE¼ sec. 17, T. 123 N., R. 39 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; some light olive-brown (2.5Y 5/4), dark grayish-brown (10YR 4/2) in places when rubbed; cloddy structure breaking to weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

C1ca—8 to 20 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, grayish-brown and yellowish-brown mottles; weak, coarse, platy structure breaking to weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—20 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, grayish-brown and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 5 to 10 inches in thickness. It is loam or clay loam in texture. The C horizon is loam and clay loam. The zone of lime accumulation is 10 to 16 inches thick and occurs beneath the A horizon.

The Langhei soils have a thinner A horizon than the Barnes soils. They are brighter colored in the C horizon and occupy steeper slopes than the Hamerly soils.

Langhei loam, 18 to 25 percent slopes (LlE).—This steeply sloping soil occurs throughout the western two-thirds of the county. It is mainly in the terminal moraine areas and on slopes by streams, waterways, sloughs, or lakes. Slopes range from 150 to 300 feet in length. Waterways that dissect the area make the cross slopes very irregular. Langhei loam makes up about 90 percent of this unit.

This soil occupies the upper part of the slopes. The surface layer is 4 to 8 inches thick and is very dark brown. However, where the soil has been cultivated, the color of the surface layer is grayish brown in places. Included with this soil in mapping are small areas of the Barnes and Darnen soils or an undifferentiated unit of Parnell and Flom soils in the waterways or at the bottom of the slopes.

Most areas of this soil are in grass, but it generally is sparse and stunted. About 900 acres of this soil has been cultivated and is severely eroded. This soil is best suited for grassland. Grazing should be restricted to prevent erosion. (Capability unit VIe–1; windbreak suitability group 5)

Langhei loam, 25 to 40 percent slopes (LlF).—This soil has very steep slopes and is in the western two-thirds of the county. It is mainly in the terminal moraine area and on slopes adjacent to streams, waterways, sloughs, and lakes. Waterways that dissect the soil areas make the cross slopes very irregular.

Included with this soil in mapping are small areas of the Barnes and Darnen soils. They are in the waterways or at the bottom of the slopes. Also included are some small areas of sand and gravel.

The steepness of the slopes causes water to run off very rapidly, and erosion is a severe hazard. These soils are in grass or trees. Where they are used for pasture, grazing should be restricted to prevent erosion. (Capability unit VIIe–1; windbreak suitability group 5)

Langhei stony loam, 6 to 40 percent slopes (LmF).—This soil is in the terminal moraine areas throughout the western two-thirds of the county. Areas of this soil are irregular in shape and size. Slopes commonly are short and choppy, and they range from 75 to 200 feet in length.

This soil is so stony that its use is greatly limited. It is best suited for use as pasture or as wildlife habitat. Areas having slopes of less than 7 percent are well suited to pasture. However, erosion is a hazard on the steeper slopes, and grazing should be restricted. (Capability unit VIIe–1; windbreak suitability group 5)

Langhei-Barnes loams, 2 to 6 percent slopes, eroded (LnB2).—These gently undulating soils occur in such intricate patterns that they were not mapped separately. These soils are in the western part of the county. Langhei loam makes up 50 percent of the soil area, and Barnes loam makes up most of the remainder.

The Langhei soil has the profile described as representative for the series. It is on slightly higher slopes than the Barnes soil and has a grayish surface layer. The Barnes soil has a darker surface layer and is in the more level areas. Included with this unit in mapping are small areas of the Svea and Hamerly soils.

Soils of this complex are farmed intensively to corn, soybeans, and small grains. The Langhei soil is less well suited to crops than the Barnes soil, because its high lime content causes an imbalance of plant nutrients. Management is needed to control erosion and maintain high levels of plant nutrients. (Both soils, capability unit IIe–2; Langhei loam, windbreak suitability group 5; Barnes loam, windbreak suitability group 1)

Langhei-Barnes loams, 6 to 12 percent slopes, eroded (LnC2).—The soils that make up this complex occupy the rolling slopes in the western two-thirds of the county. Slopes are short and irregular, and range from 75 to 300 feet in length. Langhei loam makes up 65 percent of the area, and Barnes loam, about 35 percent.

The Langhei soil is on the crests of the hills or on the upper part of the slopes. The Langhei loam has a dark grayish surface layer and appears as the light-colored areas surrounded by the darker colored Barnes soil.

The Barnes soil is in the sags and on the lower slopes below the Langhei areas. The Barnes soil generally has a black surface layer, but in places some of the subsoil has been mixed with the surface layer, and this gives these areas a brownish color. Included with this unit in mapping are small areas of the Doland, Flom, Parnell, or Vallers soils.

Soils of this complex are farmed intensively to corn, soybeans, and small grains. The Langhei soil is less suited for growing crops than the Barnes soil because of its high lime content. The organic-matter content and infiltration rate of these soils have been reduced because of erosion. Management is needed to control erosion and maintain high levels of organic matter and plant nutrients. (Both soils, capability unit IIIe–2; Langhei loam, windbreak suitability group 5; Barnes loam, windbreak suitability group 1)

Langhei-Barnes loams, 12 to 18 percent slopes, eroded (LnD2).—The soils in this complex are in the hilly areas throughout the western two-thirds of the county, mainly in the terminal moraine areas. These areas slope in several directions and are dissected by many waterways. Slopes are varied, and they range from 75 to 125 feet in length. Langhei loam makes up about 80 percent of the area, and Barnes loam makes up about 20 percent.

The Langhei soil is on the crests of the hills and the upper part of the slopes. It is grayish brown in color and appears as the light-colored areas surrounded by the darker colored Barnes soil.

The Barnes soil is in the draws on the lower slopes. Here, the surface layer is thicker than normal because soil material has washed down from the slopes above. In places where the Barnes and Langhei soils occur together, part of the subsoil of the Barnes soil generally is exposed. Included with this unit in mapping are small areas of the Doland, Flom, Parnell, or Darnen soils, and in many places, small unmappable areas of sand or gravel.

Erosion is a severe hazard because of the steepness of the slopes. Most areas of these soils are being cultivated, but they are poorly suited to crops. The organic-matter content and infiltration rate of these soils have been lowered because of erosion. Management is needed to maintain a high level of plant nutrients. (Both soils, capability unit IVe–1; Langhei loam, windbreak suitability group 5; Barnes loam, windbreak suitability group 1)

Langhei-Barnes-Sioux complex, 12 to 18 percent slopes, eroded (LoD2).—Soils of this complex are in the hilly areas of the terminal moraine in the western part of the county. Slopes range from 75 to 250 feet in length. Langhei loam makes up about 40 percent of the soil area; Barnes loam, 35 percent; and Sioux loamy sand, about 25 percent.

These soils are moderately eroded. The Langhei soil is on the upper part of the slopes. It is grayish in color and highly calcareous. The Sioux soil generally has many stones on its surface. In places near the bottom of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

Most areas of these soils are under cultivation; however, they are poorly suited to crops. Erosion and droughtiness are severe hazards. Management is needed to control erosion and maintain high levels of organic matter and plant nutrients. (All three soils, capability unit VIe–1; Langhei loam, windbreak suitability group 5; Barnes loam, windbreak suitability group 1; Sioux loamy sand, windbreak suitability group 9)

Maddock Series

The Maddock series consists of deep, well-drained soils that have developed in sandy outwash material. These nearly level to steep soils are in the western two-thirds of the county.

In a representative profile, the surface layer is neutral, very dark gray sandy loam about 6 inches thick. The subsoil is neutral, dark grayish brown in color, and about 17 inches thick. The upper part is sandy loam; the middle is loamy sand; and the lower part is sand. The underlying material is strongly calcareous to calcareous, light yellowish-brown sand.

The organic-matter content is medium. Permeability is rapid below the surface layer. The available water capacity and natural fertility are low. Soil blowing, droughtiness, and low fertility are major concerns in managing these soils. They are poorly suited to crops.

Following is a representative profile of a Maddock sandy loam in a level, cultivated field, located 250 feet east and 60 feet south of field approach in the NW¼NE¼NW¼ sec. 15, T. 123 N., R. 40 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam; cloddy; friable; neutral; abrupt, smooth boundary.

B21—6 to 8 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, very fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B22—8 to 15 inches, dark grayish-brown (10YR 4/2) loamy sand; weak, very fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B23—15 to 23 inches, dark grayish-brown (10YR 4/2) sand; single grain; loose; neutral; gradual, wavy boundary.

C1ca—23 to 30 inches, light yellowish-brown (2.5Y 6/3) sand; single grain; loose; weakly cemented; strongly calcareous; gradual, wavy boundary.

C2—30 to 60 inches, light yellowish-brown (2.5Y 6/3) sand; single grain; loose; calcareous.

The A horizon ranges from 5 to 12 inches in thickness. It is sandy loam or loamy fine sand. The C horizon is fine and medium sand. Depth to free lime is from 20 to 30 inches.

The Maddock soils have a loamy sand or sand B horizon; the Sverdrup soils have a loam or sandy loam B2 horizon. Typically, they have a more brownish colored C horizon than the Hecla soils. They have a thinner A horizon and less olive color in the B horizon than the Clontarf soils.

Maddock loamy sand, 6 to 12 percent slopes (MbC).—This soil is in the rolling and sloping areas throughout the western part of the county. Soil areas are generally elongated and have short, uniform slopes that are parallel to waterways and potholes.

This soil occurs near the Sverdrup and Langhei soils, and small areas of these soils are included with this soil in mapping. In places the surface layer on the upper part of the slopes has been moderately eroded, exposing some of the subsoil beneath. Here, the soil surface is brownish-colored loamy sand that is generally calcareous. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

Soil blowing is a hazard in fields left bare during winter and spring. Water erosion is a hazard early in summer. Droughtiness and low fertility are persistent hazards. All the common crops are grown on this soil, but it is poorly suited to them. Management is needed to control soil erosion, to maintain high levels of organic matter and plant nutrients, and to conserve moisture. (Capability unit VIs–1; windbreak suitability group 6)

Maddock loamy sand, 12 to 25 percent slopes (MbE).—This soil is in the hilly and steep areas in the western part of the county, and particularly in the morainic belt in the central part of the county. It has short, uniform slopes that range from 75 to 200 feet in length. Soil areas are generally elongated and lie parallel to the waterways or potholes.

This soil occurs closely with the Sverdrup and Sioux soils, and small areas of these soils are included with this soil in mapping. On the upper part of the slopes, this soil has been moderately eroded and in places the surface layer is thinner and lighter colored than normal. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

Droughtiness, low fertility, and water erosion are the major concerns in managing this soil. It is a good source of sand for road construction. (Capability unit VIIs–1; windbreak suitability group 6)

Maddock sandy loam, 0 to 2 percent slopes (MdA).—This soil is in the level and nearly level areas in the western part of the county, mainly in Hoff Township. Soil areas are broad and irregular in shape. Fence-row drifts commonly occur in the soil areas.

This soil has the profile described as representative for the series. It occurs near the Sverdrup, Renshaw, and Hecla soils. Small areas of those soils are included with this soil in mapping. The Sverdrup soils are in the lower positions of the soil area. In places small areas of this Maddock soil have been moderately eroded by wind. These eroded areas are pale-brown loamy sand, and generally the surface layer is calcareous. In some places, finer textured material is at a depth of less than 40 inches.

All the common crops are grown on this soil, but it is poorly suited to them. Crops that mature early make better use of the limited amount of available moisture. Soil blowing is a severe hazard in unprotected fields during winter and spring. Droughtiness is a serious limitation late in summer. Management is needed to control erosion and maintain a high content of organic matter and plant nutrients. (Capability unit IVs–1; windbreak suitability group 6)

Maddock sandy loam, 2 to 6 percent slopes (MdB).—This soil is in the gently undulating areas in the western part of the county, mainly in Hoff Township. Soil areas are irregular in shape but in places they are elongated. They lie parallel to the waterways or sloughs. Fence-row drifts are common.

This soil occurs closely with the Sverdrup and Renshaw soils. Small areas of these soils are included with this soil in mapping. Some of this soil, particularly on the upper part of the slopes, has been moderately eroded. It is brownish-colored loamy sand, and the surface layer is calcareous in places. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

Corn, soybeans, and small grains are commonly grown on this soil, but it is poorly suited to them. Crops that mature early make better use of the limited amount of available moisture. Soil blowing is a severe hazard in fields left bare during winter and spring. Droughtiness is a severe hazard late in summer. Management is needed to control erosion and maintain high levels of organic matter and plant nutrients. (Capability unit IVs–1; windbreak suitability group 6)

Malachy Series

The Malachy series consists of deep, moderately well drained soils that have developed in calcareous loamy material and in the underlying calcareous outwash sand. This is a nearly level soil that occurs in the outwash areas in Hoff Township.

In a representative profile, the surface layer is calcareous, black sandy loam in the upper 14 inches. The lower 4 inches is strongly calcareous, very dark gray sandy loam. The subsoil is strongly calcareous sandy loam about 8 inches thick. It is dark grayish brown in the upper part and olive brown in the lower part. The underlying material is calcareous, light olive-brown sand.

The organic-matter content is high, but natural fertility is medium. The available water capacity is low. Permeability is moderately rapid in the surface layer and subsoil, and rapid in the underlying material. Management is needed to control soil blowing and to maintain a high level of plant nutrients. If rainfall is adequate, these soils are moderately well suited to crops.

Following is a representative profile of Malachy sandy loam, 0 to 2 percent slopes, located 150 feet west and 50 feet south of field approach in the NW¼NW¼ sec. 31, T. 123 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A12—7 to 14 inches, black (10YR 2/1) sandy loam; weak, medium, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

A13—14 to 18 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

B21—18 to 21 inches, dark grayish-brown (2.5Y 4/2) sandy loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

B22—21 to 26 inches, olive-brown (2.5Y 4/4) sandy loam; many, fine, faint, grayish-brown and light olive-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

IIC1—26 to 60 inches, light olive-brown (2.5Y 5/4) sand; many, fine, faint, grayish-brown mottles; single grain; loose; calcareous.

The A horizon ranges from 12 to 20 inches in thickness. The zone of maximum lime accumulation ranges from a depth of 16 to 24 inches. The C horizon is generally medium sand but includes fine and coarse sand.

Typically, the Malachy soils are calcareous throughout the profile whereas the Clontarf soils are noncalcareous in the upper part. They have a more olive colored B horizon than the Maddock soils. They are finer textured than the Hecla soils.

Malachy sandy loam, 0 to 2 percent slopes (Mf).—This soil is in areas that are generally elongated and lie in a southeasterly direction. Some areas are irregular and circular.

This soil occurs near the Clontarf, Hecla, Arveson, and Marysland soils. Small areas of these soils are included with this soil in mapping. Also included are places where the zone of lime accumulation is at a depth of less than 16 inches.

Corn, soybeans, and small grains are the major crops grown on this soil. It is moderately well suited to them. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control soil erosion and maintain high levels of organic matter and plant nutrients. Applications of nitrogen, phosphorus, and potassium are also needed. (Capability unit IIIs–3; windbreak suitability group 8)

Marsh

Marsh (0 to 2 percent slopes) (Mk) consists of undrained depressions that contain water most of the year. These areas are covered by a dense growth of reeds, sedges, and rushes, but many other areas are covered by water. Drainage is not feasible at the present time.

Areas of Marsh provide excellent food and cover for many kinds of wildlife. (Capability unit VIIIw–1; windbreak suitability group 10)

Marysland Series

The Marysland series consists of poorly drained soils that are moderately deep over sand. They have developed in strongly calcareous, loamy material and in the underlying calcareous sand. These nearly level soils are associated with lake deposits. They are mainly in the southern part of Hoff Township and in White Bear Lake Township west of Lake Minnewaska.

In a representative profile, the surface layer is calcareous to strongly calcareous loam about 10 inches thick. The upper part is black loam, and the lower part is very dark gray loam. The upper 6 inches of the underlying material is strongly calcareous, gray loam. This grades to a calcareous, olive-gray loam in the middle portion. Below a depth of about 26 inches, it is variegated olive-gray, light olive-brown, and yellowish-brown coarse sand.

The organic-matter content is high, but natural fertility is only moderate because the high lime content causes an imbalance of plant nutrients. The available water capacity is moderate. Permeability is moderate in the loam and rapid in the sand. During spring the high water table limits the zone of root development. Most areas of the Marysland soils are under cultivation. Wetness and infertility are major limitations.

The following is a representative profile of Marysland loam 200 feet west of the railroad crossing, located in the SE¼SW¼ sec. 19, T. 123 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) loam, with channels of very dark gray (10YR 3/1); high in content of medium sand; cloddy; friable; calcareous; abrupt, wavy boundary.

A3ca—7 to 10 inches, very dark gray (10YR 3/1) loam, with channels of dark gray (10YR 4/1); weak, fine, granular structure; friable; strongly calcareous; abrupt, irregular boundary.

C1ca—10 to 16 inches, gray (5Y 5/1) loam; high in content of carbonate clay; few channels of dark gray (5Y 4/1); weak, coarse, platy structure breaking to weak, fine, granular; strongly calcareous; abrupt, irregular boundary.

C2—16 to 26 inches, olive-gray (5Y 5/2) loam; few, fine, faint, olive-brown, dark-brown, and strong-brown mottles; few olive-gray (5Y 4/2) tongues; weak, very fine, subangular blocky structure with horizontal cleavage; friable; calcareous; gradual, wavy boundary.

IIC2—26 to 60 inches, variegated olive-gray (5Y 5/2), light olive-brown (2.5Y 5/6), and yellowish-brown (10YR 5/8) coarse sand; single grain; loose; calcareous.

The A horizon ranges from 6 to 14 inches in thickness. It is loam, sandy clay loam, sandy loam, or silt loam. The lower part of the A horizon is dark gray or very dark gray in color but becomes lighter with increasing depth. The zone of lime accumulation ranges from 6 to 15 inches in thickness. The lower part of the C horizon begins at a depth of 22 to 40 inches and is generally medium to coarse sand. In places thin, stratified loamy layers are in the lower part of the C horizon.

Typically, the Marysland soils are more calcareous than the Mayer soils. They have a coarser textured C horizon than the Colvin or Winger soils. They are deeper over the sandy C horizon than the Arveson soils.

Marysland loam (0 to 2 percent slopes) (Ml).—This soil is in the level and slightly depressional areas in the southern part of Hoff and White Bear Lake Townships. Soil areas are generally broad and irregular but may be elongated as broad waterways.

This soil occurs near the Arveson, Hecla, Mayer, and Colvin soils. Small areas of these soils are included with this soil in mapping. Also included are about 500 acres in the southeasterly part of Hoff Township and in the southwestern part of Langhei Township, where this Marysland soil has a silt loam surface layer and subsoil that is underlain by fine sand. This area borders the glacial till soils, and in places the loamy till material is at a depth of about 40 inches.

This soil is farmed intensively to corn, soybeans, and small grains. Soil blowing is a hazard in fields left bare during winter and spring. Most areas of this soil are drained by surface ditches. This is adequate for most years, but in years of excessive rainfall, wetness persists. Applications of nitrogen, phosphorus, and potassium are needed. (Capability unit IIw–3; windbreak suitability group 7)

Mayer Series

The Mayer series consists of poorly drained and very poorly drained soils that are moderately deep over sand and gravel. These soils have developed in loamy material and in the underlying calcareous sand and gravel. They occur as slightly depressional, level areas in the gravel outwash areas throughout the county.

In a representative profile, the surface layer is calcareous loam about 19 inches thick. The upper part is black and the lower part is very dark gray. The subsoil is calcareous, dark olive-gray loam about 4 inches thick. The upper 9 inches of the underlying material is calcareous, olive-gray loam. The lower part of the underlying material is calcareous, light olive-brown sand and gravel to a depth of 60 inches.

The organic-matter content is high, but natural fertility is only moderate because of the high lime content of the soil. The available water capacity is moderate. Permeability is moderate in the loam and rapid in the sand and gravel. Early in the season these soils have a high water table, which limits the zone of root development.

Following is a representative profile of a Mayer loam in a level meadow, located 90 feet east and 45 feet south of the NW. corner of sec. 31, T. 125 N., R. 39 W.

A11—0 to 7 inches, black (N 2/0) loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A12—7 to 19 inches, very dark gray (2.5Y 3/1) loam; weak, very fine, subangular blocky structure; friable; calcareous; clear, irregular boundary.

B2g—19 to 23 inches, dark olive-gray (5Y 3/2) loam; weak, very fine, subangular blocky structure; sticky; calcareous; gradual, wavy boundary.

C1g—23 to 32 inches, olive-gray (5Y 5/2) loam; few, fine, prominent, yellowish-brown mottles; weak, fine, subangular blocky structure; sticky; calcareous; clear, wavy boundary.

IIC2—32 to 60 inches, light olive-brown (2.5Y 5/4) sand and gravel; many, medium, prominent, yellowish-brown and olive-gray mottles; single grain; loose; calcareous.

The A horizon ranges from 10 to 24 inches in thickness. It is silt loam, loam, or clay loam in texture. Depth to sand and gravel ranges from 24 to 40 inches, but is generally 30 inches.

The Mayer soils lack the strongly calcareous horizons of the Marysland soils.

Mayer loam (0 to 2 percent slopes) (Mn).—This soil occurs closely with the Renshaw, Estherville, Fordville, Wadena, and Osakis soils. Small areas of the Osakis, Wadena, and Fordville soils are included with this soil in mapping. Also included are a few small depressional areas that are very poorly drained or in which the sand and gravel is at a depth of more than 40 inches. This soil has the profile described as representative for the series.

All the common crops are grown on this soil. Most acreage of this soil has been artificially drained and is under cultivation. However, drainage remains a serious concern because suitable outlets generally are lacking. Management is needed to provide adequate drainage and to maintain a high content of plant nutrients. Applications of nitrogen, phosphorus, and potassium are also needed to offset effects of the high lime content. (Capability unit IIw–3; windbreak suitability group 7)

Mayer loam, depressional (0 to 2 percent slopes) (Mo).—This soil is in the deeply set depressions in the outwash areas throughout the county. Areas of this soil are mostly in enclosed, circular potholes but may be in elongated waterways. This soil is flooded in spring and generally throughout the year. Included with this soil in mapping are small areas of Arveson loam or Muck over sand.

If this soil is undrained, it is generally covered with reeds, sedges, rushes, and, in some places, stunted shrubs and trees. Areas of Marsh are shown on the soil map by wet symbols. These undrained areas are well suited for use as wildlife habitat.

If artificially drained this soil is used as hayland, pasture, or cropland. If adequately drained, it is suited to all crops common in the county. Crop growth is reduced in years of above-normal rainfall. (Capability unit IIIw–3; windbreak suitability group 7)

Mayer Series, Sandy Subsoil Variant

This series consists of moderately deep, poorly drained soils that have developed in loamy material and in the underlying calcareous sand and gravel. These soils are in the slightly depressional level areas in the outwash areas throughout the county.

In a representative profile, the surface layer is neutral loam about 17 inches thick. It is black in the upper 10 inches and very dark gray in the lower part. The subsoil is about 10 inches thick. It is dark grayish-brown, neutral sandy clay loam in the upper part and calcareous, grayish-brown loam in the lower part. The underlying material is calcareous, dark grayish-brown coarse sand in the upper part and grayish-brown medium and coarse sand in the lower part to a depth of 60 inches.

The organic-matter content is high, but natural fertility is only moderate. The available water capacity is moderate. Permeability is moderate in the loamy material, and very rapid in the sand and gravel. These soils are generally cultivated; however, the high water table limits the zone of root development.

Following is a representative profile of Mayer loam, sandy subsoil variant, having a slope of 1 percent, 300 feet west of the grove and 100 feet north of the farm road, in the SW¼NE¼ sec. 15, T. 125 N., R. 36 W.

Ap—0 to 6 inches, black (10YR 2/1) loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A13—10 to 17 inches, very dark gray (2.5Y 3/1) loam; weak, fine, subangular blocky structure; friable; tongues of black extend to a depth of 15 inches; neutral; clear, irregular boundary.

B21g—17 to 21 inches, dark grayish-brown (2.5Y 4/2) sandy clay loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B22g—21 to 27 inches, grayish-brown (2.5Y 5/2) loam; few, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

IIC1—27 to 31 inches, dark grayish-brown (2.5Y 4/2) coarse sand; single grain; loose; calcareous; gradual, wavy boundary.

IIC2—31 to 60 inches, grayish-brown (2.5Y 5/2) medium and coarse sand; single grain; loose; calcareous.

The A horizon ranges from 10 to 24 inches in thickness. It is silt loam, loam, or clay loam in texture. Depth to sand and gravel ranges from 18 to 40 inches but is generally about 24 inches.

Typically, the Mayer soils have a less calcareous solum than the Marysland soils.

Mayer loam, sandy subsoil variant (0 to 2 percent slopes) (Mr).—This soil occurs throughout the county but is mainly in the outwash areas in the eastern part of the county. It occupies slightly depressional areas, generally near the streams or waterways.

This soil occurs near the Estherville, Renshaw, Mayer, and Marysland soils, and small areas of these soils are included with this soil in mapping. In some places the surface layer is strongly calcareous. The underlying material is mostly coarse and medium sand, but in places it may be partly gravel. Also included are small areas in which the sand is at a depth of less than 18 inches.

All of the common crops are grown on this soil. However, this soil has a fluctuating water table and needs additional drainage. Most areas have been drained by surface ditches, which are adequate in most years. This soil is moderately well suited to well suited to crops if the soil has been properly drained. Wetness is the most serious limitation because it is generally difficult to obtain suitable drainage outlets. Soil blowing is a hazard in fields left bare during winter and spring. Management is needed to control erosion, provide adequate drainage, and maintain a high content of plant nutrients. (Capability unit IIw-3; windbreak suitability group 7)

McIntosh Series

The McIntosh series consists of deep, moderately well drained soils that have developed in calcareous, water-deposited silty material overlying calcareous loam glacial till. These nearly level soils are in the southeastern part of Hoff Township and the southern part of White Bear Lake Township.

In a representative profile, the surface layer is calcareous, black silt loam in the upper 8 inches. It is strongly calcareous, very dark gray silt loam in the lower 5 inches. The upper 15 inches of the underlying material is strongly calcareous, dark grayish-brown silt loam and silty clay loam. The lower part is calcareous, light olive-brown loam to a depth of 60 inches.

The organic-matter content and available water capacity are high, but natural fertility is only moderate because the high lime content causes an imbalance of plant nutrients. Permeability is moderate. Most areas of these soils are under cultivation. They are well suited to crops if they are properly managed.

Following is a representative profile of McIntosh silt loam, 0 to 2 percent slopes, located in a nearly level, cultivated field, 200 feet east and 100 feet south of field approach, in the NW¼SW¼ sec. 24, T. 123 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1ca—8 to 13 inches, very dark gray (10YR 3/1) silt loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

C1ca—13 to 16 inches, dark grayish-brown (2.5Y 4/2) silt loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

C2ca—16 to 28 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

IIC3—28 to 33 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

IIC4—33 to 60 inches, light olive-brown (2.5Y 5/4) loam; many, fine, prominent, yellowish-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 8 to 14 inches in thickness. It is silt loam or silty clay loam. The zone of lime accumulation is 12 to 24 inches thick. Thickness of the silt cap ranges from 18 to 40 inches but generally is about 24 inches.

The McIntosh soils differ from the Bearden soils by being underlain by glacial till. The solum of the McIntosh soils formed in sorted silt loam material, whereas the Hamerly soils formed in glacial till. They are similar to the Winger soils, but are more brownish in the Cca horizon.

McIntosh silt loam, 0 to 2 percent slopes (Ms).—This soil has slightly convex slopes.

Small areas of the Colvin, Winger, Bearden, Tara, Hamerly, and Colvin, depressional, soils are included with this soil in mapping. The Colvin and Winger soils occupy the lower slopes, and the Colvin, depressional, soil is in the depressions. The Hamerly soil is on the slight rises where the glacial till is exposed. In some places part of the surface layer may be leached to a depth of 5 to 10 inches. In other places it may be higher in lime than usual and have a grayish surface color.

All the common crops are grown on this soil. Soil blowing is a hazard in fields left bare during winter and spring. Management is needed to control soil erosion and maintain a high level of plant nutrients. Applications of nitrogen, phosphorus, and potassium are also needed. (Capability unit IIe-4; windbreak suitability group 5)

Muck

Muck consists of organic soils that generally occur in depressional areas throughout the county. They also occur in deep potholes and in nearly level to gently sloping areas.

Muck (0 to 2 percent slopes) (Mt).—This soil is in the deeply set potholes throughout the county, but mainly in the large, low-lying drainageways in the eastern third of the county. It is flooded during spring and, in many places, throughout the year. Included with this soil in mapping are small areas that are underlain in places by loamy or sandy material at a depth of less than 40 inches.

If this soil is not drained, it is covered by reeds, sedges, rushes, and, in some places, stunted shrubs and trees. Marshes are shown on the soil map by wet symbols. Marshes are well suited as wildlife habitat. Many areas of this soil lack adequate outlets for artificial drainage.

If artificially drained, this soil is used as hayland, pasture, or cropland. Shallow ditches will remove surface water adequately to provide good hayland or pasture. Deep ditches remove surface water adequately to provide cropland; however, wetness persists. If adequately drained, all the crops common in the county can be grown on this soil. Silage corn is well suited to this soil. However, small grains tend to lodge, and corn and soybeans may not reach maturity. Soil blowing is a hazard in fields left bare during winter and spring. (Capability unit IIIw-5; windbreak suitability group 10)

Muck, calcareous (0 to 2 percent slopes) (Mu).—This soil is in the deep potholes throughout the county, but it is mainly in the large, low-lying drainageways in the eastern third of the county. It is flooded in spring and, in many places, throughout the year. Included with this soil in mapping are small areas that are underlain by loamy or sandy material at a depth of less than 40 inches.

If this soil is not drained, it is covered by reeds, sedges, rushes, and, in some places, stunted shrubs and trees. Marshes are indicated on the soil map by wet symbols.

Marshes are well suited as wildlife habitat. Many areas of this soil lack adequate outlets for artificial drainage.

If drained, this soil is used as hayland, pasture, or cropland. Shallow ditches will remove water adequately to provide good hayland or pasture. Deep ditches will remove surface water and lower the water table so that crops can be grown. However, flooding and wetness persist.

If adequately drained, all the crops common in the county are grown on this soil. Silage corn is well suited to this soil. However, small grains tend to lodge, and corn and soybeans generally do not reach maturity. Soil blowing is a hazard in fields left bare during winter and spring. Natural fertility is low because of the high lime content. (Capability unit IIIw–5; windbreak suitability group 10)

Muck, calcareous, seeped (0 to 2 percent slopes) (Mv).—This soil is in the nearly level to gently sloping areas that generally are small in size. They are irregular in shape but are generally elongated, and the long axis lies across the slope. This soil occurs throughout the county, mainly in the hilly terminal moraine areas. It occurs mainly along Lake Minnewaska, particularly near the city of Glenwood, and also along the valley of Mud Creek in Lake Johanna and Gilchrist Townships.

This soil is commonly on the middle or lower slopes. It is calcareous, has a mucky surface layer, and has variable texture within the profile.

Throughout most of the year the surface of this soil is covered by slowly flowing water. During long dry periods the surface commonly becomes dry; however, the water table remains within 1 foot of the surface. Draining these areas is very difficult because the source of water must be located and diverted. This soil is generally used for pasture, but it becomes very hummocky. It is suitable for wildlife use. (Capability unit VIIIw–1; windbreak suitability group 10)

Muck, calcareous, over loam (0 to 2 percent slopes) (Mw).—This soil has developed in calcareous organic material that is 18 to 40 inches thick and overlies calcareous loamy material. It is in the large depressional areas throughout the county that were formerly shallow lakes or ponds. Included with this soil in mapping are small areas of the Blue Earth, Oldham, or Parnell soils. This Muck soil is flooded during spring and generally throughout the year.

If this soil is undrained, it is covered by reeds, sedges, rushes, or stunted shrubs and trees. Marshes are shown on the soil map by wet symbols. Marshes are well suited as wildlife habitat.

If drained, this soil is used as hayland, pasture, or cropland, depending on the drainage system used. Shallow ditches remove enough surface water to provide good hayland or pasture. Deep ditches will lower the water table adequately to provide cropland. Wetness, however, persists. A tile drainage system provides the best drainage.

If adequately drained, this soil is used to grow all crops in the county. However, small grains tend to lodge, and corn and soybeans do not always reach maturity. Wetness, low fertility, frost damage, and soil blowing are major concerns in managing this soil. (Capability unit IIIw–5; windbreak suitability group 10)

Muck, calcareous, over sand (0 to 2 percent slopes) (Mx).—This soil has developed in calcareous organic material that is 18 to 40 inches thick over sand. It occurs in the depressional areas, mainly in the eastern part of the county. In parts of Bangor Township, this soil has a loamy layer 10 to 18 inches thick that lies below the muck and above the sand.

This soil is flooded during spring and commonly throughout the year. It is covered by reeds, sedges, rushes, and, in places, stunted trees or shrubs. This soil is well suited for use as wildlife habitat. If adequately drained, all the common crops can be grown on this soil. However, small grains tend to lodge, and corn and soybeans generally do not reach maturity. (Capability unit IVw–1; windbreak suitability group 10)

Muck over loam (0 to 2 percent slopes) (My).—This soil has developed in 18 to 40 inches of organic material over loam. It occurs throughout the county in large depressional areas that were shallow lakes or ponds. Small areas of the Blue Earth, Oldham, or Parnell soils are included with this soil in mapping. It is flooded during spring and commonly throughout the year.

If this soil is undrained, it is covered by reeds, sedges, rushes, or stunted shrubs or trees. Marshes are shown on the soil map by wet symbols. These undrained areas are well suited for use as wildlife habitat.

If drained, this soil is used as hayland, pasture, or cropland, depending on the drainage system used. Shallow ditches remove enough surface water to provide good hayland or pasture. Deep ditches will lower the water table adequately to provide cropland, but wetness persists. A tile drainage system provides the best drainage.

If adequately drained, this soil can be used to grow all the crops common in the county. However, small grains tend to lodge, and corn and soybeans do not always reach maturity. Wetness, low fertility, frost damage, and soil blowing are major concerns in managing this soil. (Capability unit IIIw–5; windbreak suitability group 10)

Muck over sand (0 to 2 percent slopes) (Mz).—This soil has developed in 18 to 40 inches of organic material over sand. It is in large depressional areas, mainly in the outwash areas in the eastern part of the county. Small areas of Mayer loam, depressional, or Muck thicker than 40 inches are included with this soil in mapping. The Muck over sand is flooded during spring and generally throughout the year.

If this soil is undrained, it is covered by reeds, sedges, rushes, and, in places, stunted shrubs or trees. Marshes are shown on the soil map by wet symbols. This undrained soil is well suited for use as wildlife habitat.

If drained this soil is used as hayland, pasture, or cropland, depending on the drainage system used. Shallow ditches will remove surface water adequately to provide good hayland or pasture. Deep ditches will lower the water table adequately to provide cropland. However, wetness remains a hazard.

If adequately drained, this soil is suited to all the crops common in the county. Silage corn is well suited, but small grains tend to lodge, and corn or soybeans may not reach maturity. Wetness, low fertility, frost damage, and soil blowing are major concerns in managing this soil. (Capability unit IVw–1; windbreak suitability group 10)

Nicollet Series

The Nicollet series consists of deep, moderately well drained soils that have developed in calcareous loam glacial till. These nearly level soils are in the glacial moraine areas in the eastern part of the county.

In a representative profile, the surface layer is neutral, mainly black loam about 15 inches thick. The subsoil is neutral clay loam about 15 inches thick. In the upper part it is very dark grayish brown, and it grades to dark grayish brown in the lower part. The underlying material is calcareous loam. It is light olive brown in the upper part and grayish brown in the lower part.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate. Most areas of these soils are under cultivation. They are well suited to crops if they are properly managed.

Following is a representative profile of a Nicollet loam having a slope of 1 percent, in a cultivated field, located 110 feet west and 185 feet north of the culvert near the SE. corner of sec. 9, T. 126 N., R. 36 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; moderate, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—8 to 12 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A13—12 to 15 inches, very dark brown (10YR 2/2) loam, very dark gray (10YR 3/1) when crushed; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—15 to 19 inches, very dark grayish-brown (10YR 3/2) clay loam; moderate, medium, subangular blocky structure; friable; patchy clay films; netural; gradual, wavy boundary.

B22—19 to 26 inches, dark grayish-brown (10YR 4/2) clay loam; few, fine, faint, yellowish-brown mottles; moderate, medium, subangular blocky structure; friable; patchy clay films; neutral; gradual, wavy boundary.

B3—26 to 30 inches, dark grayish-brown (2.5Y 4/2) clay loam; few, fine, distinct, yellowish-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1—30 to 33 inches, light olive-brown (2.5Y 5/3) loam; moderate, fine, distinct, yellowish-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2—33 to 60 inches, grayish-brown (2.5Y 5/2) loam; moderate, fine, prominent, yellowish-brown mottles; massive; friable; calcareous.

The A horizon ranges from 10 to 18 inches in thickness. It is loam and clay loam. The B horizon is 6 to 16 inches thick. Lime is leached to a depth of 20 to 36 inches but generally is leached to a depth of about 30 inches.

The Nicollet soils have a thicker A horizon than the Clarion soils, and the B horizon is typically dark grayish brown rather than brown. They have a coarser textured solum than the Tara soils.

Nicollet loam, 0 to 3 percent slopes (Nc).—This soil occurs near the Clarion, Webster, and Glencoe soils. Small areas of these soils are included with this soil in mapping. The soil in this unit has the slightly convex slopes below the Clarion soil. It is in a slightly higher position than the Webster soil. In some places this soil is lighter in color and calcareous on the slight rises. In Westport Township some areas of this soil have a well-developed subsoil that has higher clay content, strong structure, and clay films.

This Nicollet soil is farmed mostly to corn and soybeans, to which it is well suited. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to keep good tilth, to maintain a high level of organic matter and plant nutrients, and to control erosion. (Capability unit I–1; windbreak suitability group 1)

424-010—72——3

Nutley Series

The Nutley series consists of deep, moderately well drained soils that have developed in calcareous, loamy glacial till. These nearly level soils are in the northern part of the county.

In a representative profile, the surface layer is neutral, black silty clay loam about 12 inches thick. The subsoil is neutral clay about 17 inches thick with clay films in the upper 11 inches. It is very dark grayish brown in the upper part, and it grades to dark grayish brown in the lower part. The underlying material is calcareous to strongly calcareous, mottled, grayish-brown clay loam in the upper 3 inches and grayish-brown silt loam in the lower part to a depth of 60 inches.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is very slow. These soils are farmed intensively and are well suited to crops.

Following is a representative profile of a Nutley silty clay loam, located 210 feet west and 20 feet south of field approach in the NW¼NE¼ sec. 7, T. 126 N., R. 38 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; cloddy, breaking to weak, very fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—8 to 12 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B1—12 to 20 inches, very dark grayish-brown (10YR 3/2) clay; strong, fine, subangular blocky structure; friable; continuous clay films on all ped faces; tongues of black from the above horizon extend through this horizon; neutral; gradual, wavy boundary.

B2—20 to 23 inches, dark grayish-brown (2.5Y 4/2) clay; many, fine, distinct, yellowish-brown mottles; weak, medium, subangular blocky structure; friable; continuous clay films on all ped faces; neutral; gradual, wavy boundary.

B3—23 to 29 inches, dark grayish-brown (2.5Y 4/2) clay; many, fine, distinct ,yellowish-brown mottles; weak, medium, subangular blocky structure; friable; patchy clay films; neutral; gradual, wavy boundary.

C1—29 to 32 inches, grayish-brown (2.5Y 5/2) clay loams; many, fine, distinct, yellowish-brown mottles; massive; friable; calcareous; gradual, wavy boundary.

IIC2ca—32 to 40 inches, grayish-brown (2.5Y 5/2) silt loam; many, fine, distinct, yellowish-brown and light brownish-gray mottles; massive; friable; few, white lime concretions; strongly calcareous; gradual, wavy boundary.

IIC3—40 to 60 inches, grayish-brown (2.5Y 5/2) silt loam; many, fine, distinct, yellowish-brown mottles; massive; friable; calcareous.

The A horizon ranges from 10 to 16 inches in thickness. It is silty clay loam or clay loam. The B horizon ranges from 12 to 20 inches in thickness and is heavy clay loam or clay. Lime is leached to a depth of 22 to 36 inches. The C horizon is loam, clay loam, or silt loam.

The Nutley soils are finer textured than the Svea soils. They have a thicker A horizon than the Forman soils.

Nutley silty clay loam, 0 to 2 percent slopes (NuA).—This soil is only in a few areas, mainly in sections 6 and 7 of Reno Township. It has the profile described as representative for the series. It occurs near the Forman and Barnes soils and an undifferentiated unit of Parnell and Flom soils. It is in the level areas below the Forman and

Barnes soils and above the Parnell and Flom soils. Small areas of these soils are included with this soil in mapping.

This soil is farmed mainly to corn and soybeans. It is moderately well suited to well suited to these crops. This soil will compact if tilled when wet. Large cracks develop in the surface layer when it dries out. It is sticky when wet and hard when dry. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to keep good soil tilth and a high level of plant nutrients. (Capability unit IIe-1; windbreak suitability group 1)

Nutley silty clay loam, 2 to 6 percent slopes (NuB).—This gently sloping soil is only in a few areas in the northern part of the county, mainly in sections 6 and 7 of Reno Township. It occurs near the Forman, Barnes, and Langhei soils. Small areas of these soils are included with this soil in mapping.

This soil is farmed intensively to corn and soybeans. This soil is easily compacted if tilled when wet. Large cracks appear in the soil when it dries out. Erosion may be hazard on some slopes. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to provide good tilth, to maintain a high content of organic matter and plant nutrients, and to control erosion. (Capability unit IIe-1; windbreak suitability group 1)

Oldham Series

The Oldham series consists of deep, poorly drained, calcareous soils that have developed in deeply set potholes and sloughs in the western two-thirds of the county.

In a representative profile, a thin layer of calcareous muck is on the soil surface. The surface layer is calcareous, black silty clay loam about 30 inches thick. The underlying material extends to a depth of 60 inches and is calcareous, dark-gray silty clay loam with a few olive mottles.

The organic-matter content and available water capacity are high, but natural fertility is only moderate because of the high lime content. Permeability is moderately slow. The water table is high, and this generally restricts the zone of root development. Drainage is needed to remove excess surface water. In areas where these soils are adequately drained, they are farmed intensively to corn and soybeans. If this soil is undrained, it is well suited for use as wildlife habitat.

Following is a representative profile of Oldham silty clay loam, located in an undrained depression, 90 feet south and 480 feet east of the NW. corner of sec. 6, T. 125 N., R. 38 W.

O2—4 inches to 0, black (N 2/0) muck; calcareous; clear, smooth boundary.

A11—0 to 6 inches, black (10YR 2/1) highly organic silty clay loam; weak, fine, subangular blocky structure; slightly sticky; calcareous; gradual, wavy boundary.

A12—6 to 18 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure; slightly sticky; many snail shells; calcareous; gradual, smooth boundary.

A13g—18 to 22 inches, black (5Y 2/1) silty clay loam; weak, fine, subangular blocky structure; slightly sticky; few snail shells; calcareous; gradual, wavy boundary.

A14g—22 to 30 inches, black (N 2/0) silty clay loam; few, fine, faint, olive mottles; massive; slightly sticky; few snail shells; calcareous; gradual, wavy boundary.

Cg—30 to 60 inches, dark-gray (5Y 4/1) silty clay loam; few, fine, faint, olive mottles; massive; slightly sticky; calcareous; gradual, wavy boundary.

The A horizon ranges from 18 to 36 inches in thickness. It is silt loam, silty clay loam, and loam. A thin layer of muck that ranges from 2 to 8 inches in thickness generally covers the A horizon. Snail shells and gypsum crystals commonly occur throughout the profile.

Typically, the Oldham soils are calcareous throughout, whereas the Parnell soils are neutral. They have developed in glacial till, whereas the Colvin soils have developed in water-laid silty material.

Oldham silty clay loam (0 to 2 percent slopes) (Om).—Soil areas are generally elongated and irregular in shape. This soil is near the Vallers and Hamerly soils and is commonly at the outer edge of the Parnell areas. Small areas of the Parnell or Vallers soils are included in mapping.

This soil is flooded during spring but usually dries up by midsummer. Soil areas require additional drainage if they are to be cultivated. Most areas have already been drained by surface ditches and are being farmed. However, excessive surface water is common in spring, and this soil is slow to warm up, which reduces crop growth. If adequately drained, all the crops common in the county are grown on this soil. Sometimes, however, small grains will lodge, and corn does not reach maturity. Applications of nitrogen, phosphorus, and potassium are needed to offset the high lime content of the soil. (Capability unit IIIw-2; windbreak suitability group 4)

Osakis Series

The Osakis series consists of moderately well drained soils that are shallow over sand and gravel. These soils have developed in loamy material and in the underlying calcareous sand and gravel. These level and slightly depressional soils are in outwash areas throughout the county.

In a representative profile, the surface layer is neutral sandy loam about 12 inches thick. It is black in the upper part and very dark brown in the lower part. The subsoil is neutral, mottled, very dark grayish-brown sandy loam about 4 inches thick. The underlying material is calcareous, mostly mottled, coarse sand with some fine gravel. It is dark grayish brown and grayish brown in the upper part and variegated grayish brown, light olive brown, and olive brown in the lower part to a depth of 60 inches.

The organic-matter content is high, but natural fertility is low because the zone of root development is limited. The available water capacity is low. Permeability is moderately rapid in the surface and subsoil layers, and rapid in the underlying sand and gravel. Droughtiness and low fertility are major concerns in managing these soils. If rainfall is adequate, they are moderately well suited to crops.

Following is a representative profile of Osakis sandy loam, 0 to 2 percent slopes, located in a level cultivated field, 780 feet south and 650 feet east of the NW. corner of the NE¼NW¼ sec. 15, T. 123 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—8 to 12 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—12 to 16 inches, very dark grayish-brown (2.5Y 3/2) sandy loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC1—16 to 20 inches, dark grayish-brown (2.5Y 4/2) sand and gravel; few, fine, faint, light olive-brown mottles; single grain; loose; calcareous; gradual, wavy boundary.

IIC2ca—20 to 25 inches, grayish-brown (2.5Y 5/2) sand and gravel; common, fine, distinct, dark yellowish-brown mottles; single grain; loose; calcareous; gradual, wavy boundary.

IIC3—25 to 60 inches, variegated grayish-brown (2.5Y 5/2), light olive-brown (2.5Y 5/4), and olive-brown (2.5Y 4/4) sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 6 to 14 inches in thickness. It is loam or sandy loam. The B horizon ranges from 4 to 10 inches in thickness and is loam or sandy loam. Depth to sand and gravel is 12 to 22 inches. Free lime generally occurs with sand and gravel in the C horizon.

The Osakis soils have a more olive-colored, mottled B horizon than the Estherville soils. They have a gravelly C horizon that is missing in the Clontarf and Dickinson soils. They have a thinner solum than the Fordville and Wadena soils.

Osakis sandy loam, 0 to 2 percent slopes (Os).—This soil is in areas that are broad and irregular in shape. It occurs closely with the Estherville, Renshaw, and Mayer soils. Small areas of these soils are included with this soil in mapping. The Estherville and Renshaw soils are slightly higher on the slopes than the Osakis soil, and the Mayer soil is on the lower slopes. In places free lime occurs in the surface layer and subsoil. Also, in places the combined thickness of these two layers is more than 24 inches.

All the common crops are grown on this soil. Crops that mature early make better use of the limited amount of available moisture. This soil is suitable for irrigated field and vegetable crops. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed to control erosion, conserve moisture, and maintain a high level of plant nutrients. (Capability unit IIIs-1; windbreak suitability group 6)

Parnell Series

The Parnell series consists of deep, very poorly drained soils that have developed in the potholes and sloughs of the glacial moraine areas in the western two-thirds of the county.

In a representative profile, the surface layer is about 18 inches thick. It is neutral, black and very dark gray silty clay loam in the upper part. It is very dark gray silt loam in the lower part. The subsoil is neutral silty clay loam and about 20 inches thick. The upper part is very dark gray, the middle part is dark olive gray, and the lower part is olive gray. The underlying material is neutral, mottled, olive-gray clay loam to a depth of 60 inches.

The organic-matter content, available water capacity, and natural fertility are high, but permeability is only moderately slow. The water table is high, and this limits the zone of root development. Wetness is a severe hazard; however, if these soils are adequately drained and properly managed, they are well suited to crops.

Following is a representative profile of Parnell silty clay loam, located 500 feet south and 50 feet east from the NW. corner of the SW¼ sec. 8, T. 123 N., R. 38 W.

A11—0 to 11 inches, black (N 2/0) silty clay loam; cloddy; friable; neutral; clear, smooth boundary.

A12—11 to 14 inches, very dark gray (10YR 3/1) silty clay loam; weak, fine, platy structure; friable; neutral; gradual, wavy boundary.

A13—14 to 18 inches, very dark gray (10YR 3/1) silt loam; moderate, medium, platy structure; friable; neutral; gradual, wavy boundary.

B21t—18 to 24 inches, very dark gray (2.5Y 3/1) silty clay loam; moderate, fine, subangular blocky structure; friable; dark-gray bleached coatings on peds; neutral; gradual, wavy boundary.

B22t—24 to 30 inches, dark olive-gray (5Y 3/2) interior, with black (10YR 2/1) exterior, silty clay loam; strong, medium, subangular blocky structure; friable; few, fine, distinct, dark yellowish-brown root stains; continuous, black clay films on peds; neutral; gradual, wavy boundary.

B23t—30 to 38 inches, olive-gray (5Y 4/2) silty clay loam; few, fine, distinct, yellowish-brown mottles; moderate, fine, subangular blocky structure; continuous, black clay films on vertical faces of peds; neutral; gradual, wavy boundary.

C1—38 to 60 inches, olive-gray (5Y 4/2) clay loam; common, fine, prominent, yellowish-brown mottles; massive; friable; many, fine, black root channels; neutral.

In places a thin layer of muck is on the soil surface. The A horizon ranges from 10 to 30 inches in thickness. When dry, a grayish horizon that is 12 to 18 inches thick is generally evident at a depth of 6 to 20 inches. This has some characteristics of the A2 horizon. Depth to the B horizon is 14 to 30 inches. The B horizon is silty clay loam or silty clay in texture. The C horizon is generally silty clay loam but may be loam or clay loam.

Typically, the Parnell soils are noncalcareous throughout, whereas the Oldham soils are calcareous. Unlike the Tonka soils, they do not have an A2 horizon. Unlike the Perella and Flom soils, they have a textural B horizon.

Parnell silty clay loam (0 to 2 percent slopes) (Pa).—This soil is in the depressions and potholes of the glaciated areas in the western two-thirds of the county. It is flooded in spring and generally throughout the year. This soil has the profile described as representative for the series. Included with this soil in mapping are small areas of the Vallers, Flom, Tonka, or Oldham soils.

If this soil is undrained, it is covered by reeds, sedges, rushes, or stunted shrubs or trees. Areas that are in a marsh condition are shown on the soil map by wet symbols. These undrained areas are well suited for use as wildlife habitat.

If artificially drained this soil is used as hayland, pasture, or cropland, depending on the type of drainage system used. Shallow ditches will remove enough water to provide good hayland and pasture. Deep drainage ditches will lower the water table adequately to provide cropland; however, crop growth will be reduced because of wetness. A tile drainage system provides the best drainage.

If adequately drained, this soil is suited to growing all the crops common in the county. Corn for silage is well suited, but small grains tend to lodge, and corn and soybeans do not always reach maturity. (Capability unit IIIw-1; windbreak suitability group 3)

Parnell and Flom silty clay loams (0 to 2 percent slopes) (Pf).—These soils are in the slightly depressed level areas. They generally are elongated and irregular in shape. These soils occur together in such unpredictable patterns that separation of each soil is impracticable. However, in some places this unit may be nearly all Parnell or all Flom soils.

When these soils are in waterways of the rolling moraine area or at the base of the slopes, they have a thicker surface layer than normal. These soils generally contain some sand or pebbles that have been washed down from nearby slopes.

These soils occur near the Svea, Hamerly, and Vallers soils. Small areas of these soils and some small, depressional areas are included with this soil in mapping. Also included is approximately 500 acres along the south and west sides of Lake Reno. This soil area was once covered by water when Lake Reno was larger. Soil in this area has a higher clay content than normal for the Parnell and Flom silty clay loams.

These poorly drained soils require additional drainage. Commonly they are quite wet after spring runoff or after heavy rains during the summer. Open ditches will provide adequate drainage most years. However, a tile system provides the best drainage. If adequately drained, these soils are used to grow corn and soybeans. (Both soils, capability unit IIw–1; both soils, windbreak suitability group 3)

Perella Series

The Perella series consists of deep, poorly drained soils that have developed in moderately fine textured silty material laid down by water. These soils occur as slightly depressed, level areas, mainly in the southwestern part of the county.

In a representative profile, the surface layer is mainly neutral silty clay loam about 30 inches thick. It is black in the upper part and very dark gray in the lower part. The underlying material is calcareous, dark-gray silty clay loam to a depth of 60 inches.

The organic-matter content, available water capacity, and natural fertility are high. This soil is wet in spring and during periods of heavy rain because permeability is moderately slow. If these soils are adequately drained and properly managed, they are well suited to crops.

Following is a representative profile of a Perella silty clay loam, located in a level cultivated field, 90 feet north and 660 feet east of the SW. corner of the SE¼ sec. 11, T. 123 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—7 to 18 inches, black (2.5Y 2/1) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A13—18 to 22 inches, very dark gray (2.5Y 3/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when crushed; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A14—22 to 30 inches, very dark gray (2.5Y 3/1) silty clay loam, very dark grayish-brown (2.5Y 3/2) when crushed; few, fine, faint, dark yellowish-brown (10YR 3/4) mottles; weak, fine, subangular blocky structure; friable; slightly calcareous; gradual, wavy boundary.

C1—30 to 60 inches, dark-gray (2.5Y 4/1) silty clay loam; few, fine, faint, olive-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 24 to 36 inches in thickness. The texture includes silty clay loam and silt loam. Free lime is leached to a depth of 18 to 36 inches. Gypsum and manganese crystals are commonly in the lower part of the C horizon.

The Perella soils have developed in sorted silty material, whereas the Flom soils developed in glacial till. Unlike the Parnell soils, it has no textured B horizon. It is noncalcareous in the upper part of the solum, whereas the Colvin and Oldham soils are calcareous throughout.

Perella silty clay loam (0 to 2 percent slopes) (Pr).—This soil is in the nearly level to slightly depressed, level areas, mainly in Walden Township and the northwestern part of Hoff Township. Soil areas are generally irregular in shape. This soil occurs closely with the Doland, Tara, Barnes, Svea, Flom, and Colvin soils. Small areas of these soils are included with this soil in mapping. In some places thin sandy layers or glacial till material is at a depth of more than 40 inches.

Most areas of this soil have been drained by surface ditches, which are adequate for most years. However, a tile drainage system would provide the best drainage. Corn and soybeans are the main crops grown on this soil. Soil blowing is a hazard in fields left bare during winter and spring. (Capability unit IIw–1; windbreak suitability group 3)

Renshaw Series

The Renshaw series consists of somewhat excessively drained soils that are shallow over sand and gravel. These soils have developed in loamy material overlying calcareous sand and gravel. These level to rolling soils are in the western two-thirds of the county, mainly along the Chippewa and East Branch of the Chippewa Rivers.

In a representative profile, the surface layer is neutral, black to very dark brown loam about 11 inches thick. The subsoil is neutral, dark-brown loam about 8 inches thick. The underlying material is strongly calcareous to calcareous, yellowish-brown sand and gravel to a depth of 60 inches.

The organic-matter content is medium. Natural fertility is low because the zone of root development is limited. The available water capacity also is low. Permeability is moderate in the surface layer and subsoil, and rapid in the underlying sand and gravel. Droughtiness and low fertility are the major limitations of these soils. Crops generally are poorly suited, but their growth is moderate if rainfall is adequate. These soils are a good source of sand and gravel for road construction.

Following is a representative profile of a Renshaw loam, located 300 feet east and 85 feet north of the SW. corner of the NW¼NW¼ sec. 29, T. 124 N., R. 40 W.

A11—0 to 8 inches, black (10YR 2/1) loam; weak, fine ,subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—8 to 11 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B2—11 to 19 inches, dark-brown (10YR 3/3) loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC1ca—19 to 26 inches, yellowish-brown (10YR 5/4) sand and gravel; single grain; loose; strongly calcareous; gradual, wavy boundary.

IIC2—26 to 60 inches, yellowish-brown (10YR 5/4) sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 6 to 12 inches in thickness. The B horizon is 6 to 12 inches thick. Both horizons are loam, sandy loam, or silt loam in texture. The combined thickness of the solum ranges from 12 to 24 inches. Free lime occurs at the C horizon, and typically a zone of lime accumulation is in the upper part of the sand and gravel.

The Renshaw soils are underlain by sand and gravel, whereas the Sverdrup soils are underlain only by sand. They have a thicker solum than the Sioux soils and are more shallow to sand and gravel than the Fordville soils. They are less acid than the Estherville soils.

Renshaw loam, 0 to 2 percent slopes (ReA).—This soil is in the level to nearly level areas, mainly along the Chippewa and East Branch of the Chippewa Rivers. Areas of this soil are broad and irregular in shape.

This soil occurs closely with the Fordville, Sioux, and Estelline soils. Small areas of these soils are included with this soil in mapping. The Sioux soil generally has slight rises in the soil areas. In the Chippewa River valley, areas of this soil in places are loam, bordering on silt loam. In an area south of the village of Cyrus this soil is silt loam.

All the common crops are grown on this soil. Crops that mature early are better suited to this soil because of the limited amount of available moisture. Soil blowing is a hazard in unprotected fields during winter and spring. This soil is suitable for irrigated field and vegetable crops. Management is needed to control erosion, conserve moisture, and maintain high levels of plant nutrients. (Capability unit IIIs–1; windbreak suitability group 6)

Renshaw loam, 2 to 6 percent slopes (ReB).—This gently sloping soil is in the glacial moraine areas and outwash areas of the Chippewa and East Branch of the Chippewa Rivers.

This soil has the profile described as representative for the series. It occurs closely with the Barnes and Sverdrup soils in the moraine areas and with the Fordville, Estelline, and Sioux soils in the outwash areas. Small areas of these soils are included with this soil in mapping. The Fordville and Estelline soils are on the lower slopes, and the Sioux soil is on the gravelly ridges.

This Renshaw soil generally is moderately eroded on the upper part of the slopes. Here, in places the surface layer is thin and brownish colored. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

All the common crops are grown on this soil. Crops that mature early are better suited because of the limited amount of available moisture. Long dry periods reduce crop growth. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to control erosion and conserve moisture. This soil is suitable for irrigated field and vegetable crops. (Capability unit IIIe–3; windbreak suitability group 6)

Renshaw loam, 6 to 12 percent slopes, eroded (ReC2).—This soil is in the rolling areas in the western two-thirds of the county. It occurs mainly in the morainic areas but is also in the outwash areas along the Chippewa and East Branch of the Chippewa Rivers. Areas of this soil are irregular in shape. Slopes are short and complex and range from 75 to 150 feet in length.

Most areas of this soil have been moderately eroded. About two-thirds of the original surface layer has been removed. In places the plow layer has been mixed with part of the subsoil, and it gives these areas a brownish color. At the base of the slopes, where soil material has accumulated, the surface layer is thicker than normal. This Renshaw soil is alongside the Langhei, Barnes, and Sioux soils. Small areas of these soils are included with this soil in mapping. Also included are some small areas in which the combined thickness of the surface layer and subsoil is greater than 24 inches.

All the common crops are grown on this soil. Droughtiness is a severe hazard. Water erosion is a moderate hazard. This soil has a lower organic-matter content and fertility level than normal because of erosion. Management is needed to control soil erosion and conserve moisture. (Capability unit IVe–2; windbreak suitability group 6)

Salida Series

The Salida series consists of excessively drained soils that are very shallow over sand and gravel. These soils have developed in loamy outwash material and in the underlying calcareous sand and gravel. These nearly level to rolling soils are in the outwash areas in the eastern part of the county.

In a representative profile, the surface layer is neutral, black sandy loam about 8 inches thick. The subsoil is neutral, brown sand and gravel about 10 inches thick. The underlying material is calcareous, brown sand and gravel to a depth of 60 inches.

The organic-matter content is medium. The available water capacity and natural fertility are very low. Permeability is very rapid below the surface layer. Droughtiness and infertility are the major limitations of these soils. They are a good source of sand and gravel for road construction.

Following is a representative profile of a Salida sandy loam having a slope of 8 percent, located 100 feet west and 60 feet north of the SE. corner of the SW¼ sec. 14, T. 123 N., R. 36 W.

A1—0 to 8 inches, black (10YR 2/1) sandy loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B2—8 to 18 inches, brown (10YR 4/3) sand and gravel; single grain; loose; neutral; gradual, smooth boundary.

C—18 to 60 inches, brown (10YR 5/3) sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 6 to 12 inches in thickness. It is sandy loam, loamy sand, or loam in texture. In places where the A horizon is loam or sandy loam, it is less than 12 inches thick. The B horizon is loamy sand, sand, or gravelly sand. Depth to lime is 8 to 20 inches.

The Salida soils are more shallow to gravel and lack the loam or sandy loam B horizon of the Wadena and Estherville soils.

Salida sandy loam, 0 to 6 percent slopes (SdB).—This level to undulating soil is in the slight rises or short slopes by streams or waterways.

This soil occurs near the Estherville and Wadena soils. The Estherville and Wadena soils are in the lower, more level areas. In places small areas of these soils are included with this soil in mapping.

Corn, soybeans, and small grains are generally grown on this soil; however, small grains or grass is better suited. Droughtiness and low fertility are the main limitations to management of this soil. (Capability unit IVs–2; windbreak suitability group 9)

Salida sandy loam, 6 to 12 percent slopes, eroded (SdC2).—This soil has the profile described as representative for the series. It occupies the sloping and rolling areas.

Nearly two-thirds of the original surface layer has been removed by erosion. Part of the surface layer has been mixed with the subsoil, which gives the plow layer a brownish color.

This soil occurs near the Estherville soils. In places small areas of these soils are included with this soil in mapping. The Estherville soils are in the lower, more level areas.

All the common crops are grown on this soil, but grasses and small grains are better suited. Erosion is a severe hazard. (Capability unit IVs–2; windbreak suitability group 9)

Salida gravelly sandy loam, 12 to 35 percent slopes (SeF).—This soil occupies the rolling to steep slopes in the outwash area of the eastern part of the county. It generally is in the steeper areas that slope into stream valleys or marsh areas.

This soil occurs near the Estherville and Dickinson soils. Small areas of these soils are included with this soil in mapping.

This soil is poorly suited to crops. Erosion is a severe hazard on pastures that are overgrazed. Management is needed to restrict grazing and maintain a permanent grass cover. (Capability unit VIIs–1; windbreak suitability group 9)

Sioux Series

The Sioux series consists of excessively drained soils that are very shallow over sand and gravel. These soils have developed in loamy outwash material and in the underlying calcareous sand and gravel. These nearly level to steep soils are in the western two-thirds of the county, mainly in the terminal moraine areas of Barsness Township.

In a representative profile, the surface layer is neutral, very dark gray sandy loam about 8 inches thick. The underlying material is calcareous, mainly yellowish-brown coarse sand and gravel to a depth of 60 inches.

The organic-matter content is medium. The available water capacity and natural fertility are very low. Permeability is very rapid below the surface layer. These soils are a good source of sand and gravel for road construction.

Following is a representative profile of a cultivated Sioux sandy loam having slopes of 4 percent, located 260 feet north and 40 feet west of the SE. corner of the NE¼ sec. 18, T. 123 N., R. 38 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

C1—8 to 14 inches, dark grayish-brown (10YR 4/2) and yellowish-brown (10YR 5/4) coarse sand and gravel; single grain; loose; calcareous; abrupt, smooth boundary.

C2—14 to 60 inches, yellowish-brown (10YR 5/4) and light brownish-gray (10YR 6/2) coarse sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 6 to 12 inches in thickness. It is sandy loam, loamy sand, or loam. In places where the texture is loam and sandy loam, the A horizon is less than 12 inches thick. The C horizon is loamy sand or gravelly loamy sand, coarse sand, or gravel.

The Sioux soils are shallower to sand and gravel and lack the loam or sandy loam B horizon of the Fordville or Renshaw soils.

Sioux sandy loam, 0 to 6 percent slopes (SlB).—This soil is in the level to undulating outwash areas in the western two-thirds of the county. It occurs along the small streams where it is among areas of the Renshaw soils. Here, it is in slight rises or has short slopes. In the glaciated uplands, it is in the small hills and occurs near the Barnes and Langhei soils.

This soil has the profile described as representative for the series. Included with this soil in mapping are small areas of the Renshaw soils. In some places loamy material is in the underlying material.

Corn, soybeans, and small grains are generally grown on this soil. Droughtiness and low fertility are serious limitations. Crops that mature earlier are better suited. (Capabality unit IVs–2; windbreak suitability group 9)

Sioux sandy loam, 6 to 12 percent slopes, eroded (SlC2).—This sloping and rolling soil is in the glaciated and outwash areas in the western part of the county.

This soil occurs near the Barnes, Langhei, and Renshaw soils. It is commonly in the higher areas on the slopes or it may be in areas that slope into the streams or waterways. Nearly two-thirds of the original surface layer has been removed by erosion. In places part of the surface layer has been mixed with the subsoil, and this gives the surface layer a brownish color.

All the common crops are grown on this soil, but grasses and small grains are better suited. Droughtiness and low fertility are serious limitations. Erosion is a severe hazard. (Capability unit IVs–2; windbreak suitability group 9)

Sioux gravelly sandy loam, 6 to 35 percent slopes (SoF).—This undulating to steep soil is in the morainic areas in the western two-thirds of the county. It is in outwash areas of small streams and occurs as slight rises or terrace escarpments.

In many places on the steeper slopes, the surface layer has been severely eroded, and this has exposed some of the underlying gravel. In the southern part of Barsness and Chippewa Falls Townships and in the northern part of Rolling Forks and Gilchrist Townships, this Sioux soil is in the very steep range of hills that are several miles in length. This soil occurs closely with the Renshaw, Sverdrup, and Maddock soils. Small areas of these soils are included with this soil in mapping. In places where this soil is in the glacial till areas, the Barnes and Langhei soils are also included.

This soil is very droughty and is poorly suited to crops. It is better suited to permanent grass vegetation because water erosion is a severe hazard on the steep slopes. However, management is needed to prevent overgrazing. (Capability unit VIIs–1; windbreak suitability group 9)

Storden Series

The Storden series consists of deep, somewhat excessively drained soils that have developed in calcareous loam glacial till. These gently undulating to steep soils are in the northeastern part of the county.

In a representative profile, the surface layer is calcareous, very dark brown loam about 7 inches thick. The underlying material is a calcareous, mottled, light olive-brown loam.

The organic-matter content and permeability are moderate. The available water capacity is high, but natural fertility is moderate because of the high lime content. Water erosion, moderate fertility, and droughtiness are the main concerns in managing these soils. Most areas of these soils are cultivated if the slopes are not too steep. Steeper slopes are used as pasture.

Following is a representative profile of a Storden loam having a slope of 7 percent, located in a cultivated field, 1,100 feet south and 125 feet east of the NW. corner of the SW¼ sec. 10, T. 126 N., R. 36 W.

Ap—0 to 7 inches, very dark brown (10YR 2/2) loam, with grayish brown (2.5Y 5/2) intermixed; cloddy, breaking to weak, fine, blocky structure; friable; calcareous; abrupt, clear boundary.

C1—7 to 18 inches, light olive-brown (2.5Y 5/3) loam; many, fine, distinct, light brownish-gray and yellowish-brown mottles; weak, coarse, platy structure breaking to moderate, coarse, angular blocky structure; friable; calcareous; gradual, smooth boundary.

C2—18 to 60 inches, light olive-brown (2.5Y 5/4) loam; many, fine, distinct, light brownish-gray and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 6 to 10 inches in thickness. It is loam or clay loam in texture. In places a weakly developed, brownish-colored B horizon that is less than 3 inches thick is below the A horizon. The C horizon is loam or clay loam in texture.

The Storden soils have a thinner solum and are more calcareous than the Clarion soils. They have a darker surface layer and are not so calcareous as the Langhei soils.

Storden-Clarion loams, 12 to 25 percent slopes, eroded (SrE2).—The hilly and steep soils that make up this complex are in the northeastern part of the county. They slope into streams or sloughs. Soil areas are dissected by waterways and are very irregular in shape. Slopes range from 150 to 250 in length. Storden loam makes up about 75 percent of the area, and Clarion loam, 25 percent.

The Storden soil occupies the crests of the hills and the upper part of the slopes. It appears much lighter in color than the Clarion soil.

The Clarion soil is in the draws and on the lower part of the slopes. It has a very dark surface layer that is thicker than normal at the base of the slopes. In places where the Storden and Clarion soils join, part of the brown subsoil of the Clarion soil is generally exposed.

Included with this unit in mapping are small areas of Nicollet loam, Webster loam, and Glencoe silty clay loam, and in places, unmappable areas of sand and gravel. Some places have been severely eroded, and nearly all the surface layer has been removed. The color of these eroded areas is grayish brown.

About one-half of the soils of this complex are under cultivation. Erosion is a severe hazard because the slopes are steep. The organic-matter content and infiltration rate have been lowered because of soil erosion. The remainder of the soils are used as grassland or woodland. Management is needed to control erosion and maintain a high content of plant nutrients. (Both soils, capability unit IVe-1; Storden loam, windbreak suitability group 5; Clarion loam, windbreak suitability group 1)

Svea Series

The Svea series consists of deep moderately well drained soils that have developed in calcareous loam glacial till. These nearly level to gently sloping soils are in the western part of the county.

In a representative profile, the surface layer is neutral, black loam about 13 inches thick. The subsoil is neutral, very dark grayish-brown to dark grayish-brown loam about 9 inches thick. The upper part of the underlying material is calcareous to strongly calcareous, mottled, grayish-brown loam. The lower part is calcareous, light olive-brown loam.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate. Most of these soils are being farmed and are well suited to crops. They respond well to management.

Following is a representative profile of a cultivated Svea loam having a slope of 1 percent, located 20 feet south and 410 feet east of NW. corner of the SW¼ sec. 25, T. 126 N., R. 40 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—9 to 13 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—13 to 17 inches, very dark grayish-brown (2.5Y 3/2) loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B22—17 to 22 inches, dark grayish-brown (2.5Y 4/2) loam; few, fine, faint, grayish-brown and light olive-brown mottles; weak, medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1—22 to 26 inches, grayish-brown (2.5Y 5/2) loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2ca—26 to 32 inches, grayish-brown (2.5Y 5/2) loam; moderate, fine, distinct, yellowish-brown mottles; massive; friable; strongly calcareous; gradual, wavy boundary.

C3—32 to 60 inches, light olive-brown (2.5Y 5/4) loam; moderate, fine, distinct, yellowish-brown and light brownish-gray mottles; massive; friable; calcareous.

The A horizon ranges from 10 to 18 inches in thickness and is silt loam, loam, or clay loam in texture. The B horizon is 8 to 14 inches thick and is loam or clay loam in texture. Lime is leached to a depth of 16 to 24 inches. In places a continuous pebble line is in the soil profile.

The Svea soils have a thicker A horizon than the Barnes soils. They have a thinner A horizon than the Darnen soils.

Svea loam, 0 to 2 percent slopes (SuA).—This soil has the profile described as representative for the series. It is in the nearly level slopes in the western part of the county.

This soil occurs near the Barnes, Hamerly, and Tara soils and an undifferentiated unit of Parnell and Flom soils. It is on the slightly convex slopes below the Barnes soils and above the Parnell and Flom soils. In places small areas of the Barnes, Hamerly, and Parnell and Flom soils are included with this soil in mapping. In some of the slightly depressional areas the surface layer of the Svea loam is more silty than normal.

This soil is generally farmed to corn and soybeans, to which it is well suited. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to keep good soil tilth, maintain a high content of organic matter and plant nutrients, and control erosion. (Capability unit I-1; windbreak suitability group 1)

Svea loam, 2 to 4 percent slopes (SuB).—This gently sloping soil is in the glacial till areas in the western part of the county. Slopes are generally smooth and range from 75 to 150 feet in length. Areas of this soil are irregular in shape and generally less than 10 acres in size.

This soil occurs near the Barnes and Hamerly soils and an undifferentiated unit of Parnell and Flom soils. Small areas of these soils are included with this soil in mapping. The Barnes soil is above the Svea soil. The Hamerly soil occurs as light-colored, highly calcareous bumps, and the Parnell and Flom soils are in the lower depressions. In places the upper part of the slopes have been moderately eroded. Here, the surface layer is lighter in color and thinner than normal.

This soil is farmed intensively to corn and soybeans, to which it is well suited. Soil blowing is a hazard in unprotected fields during winter and spring. Erosion is a slight hazard. Management is needed to maintain a high content of organic matter and plant nutrients and to control erosion. (Capability unit IIe–1; windbreak suitability group 1)

Sverdrup Series

The Sverdrup series consists of somewhat excessively drained loamy soils that are shallow over sand. These level to rolling soils are in the western two-thirds of the county.

In a representative profile, the surface layer is neutral, black loam about 11 inches thick. The subsoil is about 18 inches thick. In the upper 9 inches, it is neutral, very dark grayish-brown loam and dark grayish-brown sandy loam. The lower 9 inches is brown sand. The underlying material is calcareous, light olive-brown sand to a depth of 60 inches.

The organic-matter content is high, but the available water capacity and natural fertility are low. Permeability is moderate in the surface layer and rapid in the underlying material. Droughtiness and low fertility are the main concerns in managing these soils. If rainfall is adequate, they are moderately well suited to crops.

Following is a representative profile of a Sverdrup loam in a level, cultivated field, located 100 feet east of the south end of the grove in the SE¼NE¼ sec. 21, T. 123 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) loam; weak, very fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B1—11 to 16 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—16 to 20 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIB3—20 to 29 inches, brown (10YR 4/3) sand; single grain; loose; neutral; gradual, wavy boundary.

IIC1—29 to 33 inches, light olive-brown (2.5Y 5/4) sand; few, fine, faint, olive-brown and grayish-brown mottles; single grain; loose; calcareous; gradual, wavy boundary.

IIC2—33 to 60 inches, light olive-brown (2.5Y 5/3) sand, pale brown (10YR 6/3) dry; single grain; loose; calcareous.

The A horizon ranges from 6 to 14 inches in thickness. It is loam or sandy loan. The B horizon is 10 to 20 inches thick. The sand in the C horizon generally is medium, but in places it contains fine gravel. Depth to free lime is 12 to 16 inches.

The Sverdrup soils have a less sandy B2 horizon than the Maddock soils. Unlike the Renshaw soils, they have little or no gravel in the IIC horizon. They have a coarser textured C horizon than the Barnes soils.

Sverdrup sandy loam, 2 to 6 percent slopes, eroded (SyB2).—This is a gently sloping to undulating soil in the western part of the county. Areas of this soil are irregular in shape.

This soil occurs near the Renshaw, Maddock, Barnes, and Langhei soils. Small areas of these soils are included with this soil in mapping. In some places the Sverdrup soil has a limy surface layer. Also in places a loamy layer is in the coarse-textured underlying material. About half of the areas of this soil, especially on the upper part of the slopes, are moderately eroded. Here, the surface layer is thinner than normal and has a brownish color because part of it has been mixed with the subsoil. In other places these eroded areas are calcareous. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal.

All the common crops are grown on this soil. Crops that mature early are better suited because of the limited amount of available moisture. Droughtiness is a persistent hazard. Soil blowing is a hazard in unprotected fields during winter and spring. Erosion is a hazard on the steeper slopes. Management is needed to conserve moisture, control erosion, and maintain a high content of organic matter and plant nutrients. (Capability unit IIIs–2; windbreak suitability group 6)

Sverdrup sandy loam, 6 to 12 percent slopes, eroded (SyC2).—This sloping and rolling soil is mainly in the strongly morainic areas in the central part of the county. Soil areas are irregular in shape but generally are elongated along the waterways.

This soil occurs near the Maddock, Renshaw, Sioux, Langhei, and Barnes soils. Small areas of these soils are included with this soil in mapping. On the upper part of the slopes, more than one-third of the original surface layer has been eroded. Here, the soil is brownish colored and is generally calcareous because some of the surface layer has been mixed with the subsoil. On the lower slopes, where soil material has accumulated, the surface layer is commonly thicker than normal.

Corn, soybeans, and small grains are grown on this soil. Crops that mature early are better suited because of the limited amount of available moisture. Droughtiness is a persistent hazard, and erosion is a moderate hazard on most slopes. Management is needed to control erosion, conserve moisture, and maintain a high content of organic matter and plant nutrients. (Capability unit IVe–2; windbreak suitability group 6)

Sverdrup loam, 0 to 2 percent slopes (SzA).—This soil is in the western part of the county, particularly in Hoff Township. It is in broad, irregularly shaped areas, usually in outwash areas along the streams.

This soil has the profile described as representative for the series. It occurs near the Renshaw, Maddock, and Barnes soils. Small areas of these soils are included with this soil in mapping. In a few places the surface layer is calcareous, and in other places a loamy layer is in the lower part of the underlying material.

This soil is farmed intensively to corn, soybeans, and small grains. Crops that mature early are better suited because of the limited amount of available moisture. Droughtiness is a persistent hazard. Soil blowing is a hazard in unprotected fields during winter and spring. Most areas of this soil are suitable for irrigated field or vegetable crops if an adequate source of water is available. Management is needed to conserve moisture, control erosion, and maintain a high content of organic matter and plant nutrients. (Capability unit IIIs–2; windbreak suitability group 6)

Tara Series

The Tara series are deep, moderately well drained soils that have developed in sorted silty material and in the underlying calcareous loam glacial till. These level to nearly level soils occur throughout the western part of the county, but mainly in Walden and Blue Mounds Townships.

In a representative profile, the surface layer is neutral, black silt loam about 15 inches thick. The subsoil is neutral silt loam about 8 inches thick. It is very dark grayish brown in the upper part, and it grades to dark grayish brown in the lower part. The upper 6 inches of the underlying material is strongly calcareous, grayish-brown loam. The lower part of the underlying material is calcareous, mottled, light olive-brown loam to a depth of 60 inches.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate. These soils are farmed intensively and are well suited to crops.

Following is a representative profile of a Tara silt loam in a level, cultivated field, located 580 feet west and 45 feet south of the NE. corner of the SE¼ sec. 2, T. 123 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; moderate, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B1—15 to 18 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—18 to 23 inches, dark grayish-brown (2.5Y 4/2) silt loam; weak, fine, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC1ca—23 to 29 inches, grayish-brown (2.5Y 5/2) loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

IIC2—29 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, grayish-brown and light olive-brown mottles; massive; friable; calcareous.

The A horizon ranges from 14 to 20 inches in thickness. Thickness of the silt cap ranges from 18 to 40 inches, but generally it is about 24 inches thick. Depth to free lime ranges from 14 to 30 inches, but generally is at the contact with the glacial till. The texture of the underlying glacial till (IIC horizon) is loam or clay loam.

The Tara soils have a silt loam solum, whereas the Svea soils have a loam solum. They have a thicker A horizon than the Doland soils and a thinner A horizon than the Darnen soils.

Tara silt loam, 0 to 3 percent slopes (Ta).—This nearly level soil is in the silt-capped areas and in the level, slightly depressed areas in the glacial moraine.

It occurs near the Doland, Barnes, Svea, and Perella soils. Small areas of these soils are included with this soil in mapping. In places the silt cap is thicker than 40 inches. Also, in places small areas of this soil have a limy surface layer. In the northeastern part of Westport Township this Tara soil is leached of lime to a depth of about 24 inches and lacks a definite zone of lime accumulation.

This soil is farmed intensively to corn and soybeans. Soil blowing is a hazard in unprotected fields during winter and spring. Management is needed to control erosion, to keep good tilth, and to maintain a high level of plant nutrients. (Capability unit I-1; windbreak suitability group 1)

Tonka Series

The Tonka series consists of deep, poorly drained and very poorly drained soils that have developed in potholes in the glacial moraine in the western two-thirds of the county.

In a representative profile, the upper 10 inches of the surface layer is slightly acid, black silt loam. The lower 6 inches is slightly acid, dark-gray very fine sandy loam that has prominent mottles. The upper 11 inches of the subsoil is slightly acid, dark olive-gray clay. The lower 11 inches is neutral, dark-gray clay. Continuous clay films occur throughout the subsoil. The underlying material is calcareous, mottled clay loam. It is gray in the upper part and olive gray in the lower part.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is very slow. Wetness is a severe hazard; however, if these soils are adequately drained and properly managed, they are well suited to crops.

Following is a representative profile of Tonka silt loam, located 890 feet east and 125 feet north of the SW. corner of the SE¼ sec. 10, T. 124 N., R. 40 W.

A1—0 to 10 inches, black (N 2/0) silt loam; moderate, fine, granular structure; friable; slightly acid; gradual, wavy boundary.

A21—10 to 14 inches, dark-gray (5Y 4/1) very fine sandy loam; many, medium, prominent, yellowish-brown mottles; strong, fine, platy structure; friable; slightly acid; gradual, wavy boundary.

A22—14 to 16 inches, dark-gray (5Y 4/1) very fine sandy loam; many, medium, prominent, yellowish-brown mottles; moderate, medium, platy structure; friable; slightly acid; gradual, wavy boundary.

B21—16 to 27 inches, dark olive-gray (5Y 3/2) clay; moderate, fine, angular blocky structure; firm, continuous clay films on all ped faces; slightly acid; gradual, wavy boundary.

B22—27 to 34 inches, dark-gray (5Y 4/1) clay; moderate, fine, subangular blocky structure; firm, continuous clay films on all ped faces; neutral; gradual, wavy boundary.

B23—34 to 38 inches, dark-gray (5Y 4/1) clay; few, fine, distinct, light olive-brown mottles; strong, fine, subangular blocky structure; firm, continuous clay films on all peds; neutral; gradual, wavy boundary.

C1—38 to 48 inches, gray (5Y 5/1) clay loam; many, fine, distinct, light olive-brown mottles; massive; friable; calcareous; gradual, wavy boundary.

C2—48 to 60 inches, olive-gray (5Y 5/2) clay loam; many, fine, prominent, yellowish-brown mottles; massive; friable; few manganese and iron concretions; calcareous.

The black A1 horizon ranges from 8 to 16 inches in thickness and is silt loam, silty clay loam, or loam in texture. The A2 horizon is 6 to 12 inches thick. It is dark gray and gray in color and is silt loam and very fine sandy loam in texture. The B horizon ranges from 12 to 28 inches in thickness and is clay and clay loam in texture. The C horizon is loam and clay loam. Depth to lime ranges from 36 to 48 inches.

The Tonka soils have an A2 horizon, which is absent in the Parnell soils. They differ from the Oldham soils which have no A2 horizon and are calcareous.

Tonka silt loam (0 to 2 percent slopes) (To).—This soil is in the shallow depressions in the ground moraine areas but mainly in the silt-capped areas in the western part of the county.

This soil is near the Doland, Tara, Barnes, Svea, Flom, and Vallers soils. In places small areas of the Vallers or the Flom soils are along the outer edge of the soil area. These areas are ponded in spring and for short periods after heavy rains. However, they generally dry up by midsummer. Much of this soil is permanently covered by trees or marsh grass, but many areas have been drained by shallow surface ditches and are under cultivation.

Corn and soybeans are grown on this soil. Wetness is a severe hazard, because this soil is in the depressional areas and permeability is very slow. Management is needed to provide adequate drainage, to keep good soil tilth, and to maintain a high level of plant nutrients. (Capability unit IIIw-1; windbreak suitability group 3)

Vallers Series

The Vallers series consists of deep, poorly drained soils that have developed in calcareous, loamy glacial till. This soil occurs as broad, level areas on rims around potholes or as slight rises within the Flom soil areas. These soils occur throughout the western two-thirds of the county.

In a representative profile, the surface layer is calcareous, black silty clay loam about 12 inches thick. The upper part of the underlying material is strongly calcareous, dark-gray to gray clay loam. The lower part is calcareous, mottled, olive-gray loam.

The organic-matter content and available water capacity are high, but permeability is moderately slow. Natural fertility is moderate because the high lime content causes an imbalance of plant nutrients. The Vallers soils have a high water table early in the year, and this limits the zone of root development. These soils are farmed mainly to corn and soybeans. Wetness and an imbalance of nutrients are the major concerns in managing these soils.

Following is a representative profile of a Vallers silty clay loam, located 600 feet east and 370 feet north of the SW. corner of the NE¼ sec. 32, T. 124 N., R. 39 W.

A11—0 to 8 inches, black (10YR 2/1) silty clay loam; moderate, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.
A12—8 to 12 inches, black (2.5Y 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable; calcareous; clear, wavy boundary.
C1ca—12 to 15 inches, dark-gray (2.5Y 4/1) clay loam; weak, very fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.
C2ca—15 to 21 inches, gray (5Y 5/1) clay loam; few, fine, distinct, grayish-brown and light olive-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.
C3—21 to 32 inches, olive-gray (5Y 5/2) loam; many, fine, distinct, light olive-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.
C4—32 to 60 inches, olive-gray (5Y 5/2) loam; many, fine, prominent, yellowish-brown mottles; massive; friable; calcareous.

The A horizon ranges from 8 to 16 inches in thickness. It is silty clay loam, silt loam, or clay loam in texture. The C horizon is loam or clay loam and is strongly mottled.

The Vallers soils has a Cca horizon, which is absent in the Perella soils. Their Cca horizon is at a shallower depth than in the Flom or Canisteo soils. They developed entirely in glacial till, whereas the Winger soils developed in silty material overlying glacial till.

Vallers silty clay loam (0 to 2 percent slopes) (Va).—This soil is in the nearly level to slightly depressional areas.

This soil occurs closely with Hamerly loam and Oldham silty clay loam. Small areas of these soils are included with this soil in mapping.

All the common crops are grown on this soil, although it is generally wet during spring and after heavy rainfalls. Most areas of this soil are drained by surface ditches, but crop growth is reduced because of wetness and low soil temperatures. When adequately drained, this soil is well suited to crops. However, soil blowing is a hazard in fields left bare during winter and spring. Management is needed to provide adequate drainage, to control erosion, and to maintain a high level of plant nutrients. Applications of nitrogen and phosphorus are also needed. (Capability unit IIw-2; windbreak suitability group 4)

Wadena Series

The Wadena series consists of well-drained soils that are moderately deep over sand and gravel. These soils have developed in a loamy material underlain by calcareous outwash sand and gravel. These soils occur as level and slightly depressional areas in the eastern third of the county.

In a representative profile, the surface layer is slightly acid, black to very dark brown loam about 25 inches thick. The subsoil is slightly acid, very dark grayish-brown, dark-brown, or dark grayish-brown loam about 11 inches thick. The underlying material is calcareous, brown and dark-brown sand and gravel.

The organic-matter content is high, but natural fertility is medium because of the limited zone of root development. The available water capacity is low. Permeability is moderate in the solum and very rapid in the underlying material. These soils are slightly droughty. They are a good source of sand and gravel for road construction.

Following is a representative profile of a Wadena loam having a slope of 1 percent, located 230 feet north and 90 feet west of the SE. corner of the NW¼ sec. 3, T. 125 N., R. 37 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; cloddy; friable; slightly acid; abrupt, smooth boundary.
A12—7 to 14 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.
A13—14 to 21 inches, black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.
A14—21 to 25 inches, very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) when dry; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.
B21—25 to 29 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.
B22—29 to 33 inches, dark-brown (10YR 3/3) loam, dark grayish brown (10YR 4/2) when dry; few, fine, faint, dark yellowish-brown mottles; weak, fine, subangular blocky structure; friable; slightly acid; gradual, wavy boundary.
B3—33 to 36 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, subangular blocky structure; friable; vesicular; slightly acid; gradual, wavy boundary.
IIC1—36 to 40 inches, brown (10YR 4/3) sand; single grain; loose; calcareous; gradual, wavy boundary.
IIC2—40 to 60 inches, dark-brown (10YR 4/3) and brown (10YR 5/3) sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 16 to 28 inches in thickness. The B horizon ranges from 8 to 16 inches in thickness. The thickness of the solum ranges from 24 to 40 inches, but it commonly is 30 inches. Depth to free lime is from 26 to 40 inches.

The Wadena soils have a thicker solum than the Estherville soils. They are more acid than the Fordville soils.

Wadena loam (0 to 2 percent slopes) (Wa).—This soil occupies the slightly depressional areas in the outwash area in the eastern part of the county.

This soil occurs near the Estherville, Wadena, and Mayer soils. Small areas of these soils are included with this soil in mapping. In some places free lime is in the upper part of the solum. In a few places mottles are in the lower part of the solum.

All the common crops are grown on this soil. Because areas are small, Wadena loam generally is farmed the same as the areas that surround it. Droughtiness is a slight hazard, and crop growth is reduced after long dry periods. Management is needed to conserve moisture, keep good soil tilth, and provide a high content of plant nutrients. Applications of nitrogen and phosphorus also are needed. (Capability unit IIs-1; windbreak suitability group 2)

Waukon Series

The Waukon series consists of deep, well-drained soils that have developed under tree vegetation in calcareous loam glacial till. These nearly level to moderately steep soils occur throughout the central and the southeastern parts of the county.

In a representative profile, the upper 7 inches of the surface layer is neutral, black loam. The lower 2 inches is very dark gray clay loam. The subsoil is neutral clay loam about 17 inches thick and has clay films. The upper part is very dark grayish brown, and this grades to brown in the lower part. The underlying material is calcareous, light olive-brown loam.

The organic-matter content, available water capacity, and natural fertility are high. Permeability is moderately slow. Water erosion is a moderate hazard in the rolling areas. Erosion control and soil management are the major concerns in using these soils. Most areas are still under tree vegetation and are well suited for use as wildlife habitat. However, many wooded areas are used for grazing cattle. In areas where these soils are under cultivation, they are moderately well suited to well suited to crops.

Following is a representative profile of a Waukon loam, on a slope of 4 percent, located 150 feet south on the trail and 65 feet west of the NE¼NE¼NW¼ sec. 7, T. 125 N., R. 38 W.

A0—2 inches to 0, duff.

A11—0 to 7 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A12—7 to 9 inches, very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; moderate, fine, subangular blocky structure; friable; patchy clay films; light-gray, bleached sand grains; neutral; gradual, wavy boundary.

B21t—9 to 14 inches, very dark grayish-brown (10YR 3/2) clay loam, with grainy gray coatings; clay loam; moderate, fine, subangular blocky structure; friable; continuous clay films on all ped faces; neutral; gradual, wavy boundary.

B22t—14 to 26 inches, clay loam; peds have brown (10YR 4/3) interior and very dark gray (10YR 3/1) exterior, strong, coarse, subangular blocky structure breaking to moderate, medium, subangular blocky; friable; clay films on vertical faces of peds; neutral; clear, irregular boundary.

C1ca—26 to 34 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; some very dark grayish-brown root channels; a few lime and iron concretions; calcareous; gradual, wavy boundary.

C2—34 to 60 inches, light olive-brown (2.5Y 5/4) loam; few, fine, faint, grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 7 to 12 inches in thickness. It is loam or clay loam in texture. A thin layer of duff commonly covers the surface. The B horizon is 10 to 20 inches thick. The C horizon is calcareous loam or clay loam. Lime is leached to the C horizon. Pebbles and stones are common throughout the profile.

The Waukon soils have a thicker solum than the Langhei soils. They have a finer textured, better developed B horizon than the Barnes soils. They differ from the Forman soils by having bleached sand particles in the lower part of the A horizon.

Waukon loam, 0 to 2 percent slopes (WbA).—This soil is on nearly level slopes, mainly in the north-central part of the county north of Lake Minnewaska. Soil areas are irregular in shape and have slightly convex slopes. Included with this soil in mapping are small areas of Barnes loam, Svea loam, and Parnell silty clay loam.

About half of this soil is under cultivation. It is moderately well suited to well suited to corn, soybeans, and small grains. Soil blowing is a hazard in fields left bare during winter and spring. The remainder of this soil is under tree vegetation and is suitable for use as wildlife habitat. Management is needed to keep good soil tilth in the cultivated areas and to prevent overgrazing of the wooded areas. (Capability unit I-1; windbreak suitability group 1)

Waukon loam, 2 to 6 percent slopes (WbB).—This soil is in the undulating areas of the wooded morainic belt that crosses the central part of the county. Slopes are short and choppy, and they range from 75 to 150 feet in length.

This soil has the profile described as representative for the series. Included with this soil in mapping are small areas of the Langhei, Barnes, and Svea soils and an undifferentiated unit of Parnell and Flom soils. In places small sandy or gravelly areas are also included in mapping. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal. Here, the colors of the subsoil are somewhat dull.

Most areas of this soil are under tree vegetation and are generally used for grazing. Management is needed to prevent overgrazing of these areas. (Capability unit IIe-1; windbreak suitability group 1)

Waukon loam, 6 to 12 percent slopes (WbC).—This soil is in the rolling areas in the wooded morainic belt that crosses the central part of the county. Slopes are short and complex, and they range from 75 to 250 feet in length.

Included with this soil in mapping are small areas of the Langhei, Barnes, and Svea soils and an undifferentiated unit of Parnell and Flom soils. In places small areas of sand and gravel are also included in mapping. On the lower part of the slopes, where soil material has accumulated, the surface layer is thicker than normal. Here, the subsoil is dull in color. This soil is under tree vegetation and is used mainly for grazing. (Capability unit IIIe-1; windbreak suitability group 1)

Waukon loam, 12 to 18 percent slopes (WbD).—This soil is in the hilly and steep areas in the wooded morainic belt that crosses the central part of the county. Slopes are complex and range from 100 to 300 feet in length.

Included with this soil in mapping are small areas of Langhei, Barnes, and Svea soils and an undifferentiated unit of Parnell and Flom soils. Also included in mapping are small areas of sand and gravel. On the upper part of the slopes the surface layer is thinner than normal and occurs closely with small areas of Langhei loam. On the lower part of the slopes, where soil material has accumulated, the surface layer is much thicker than normal. This soil is under tree vegetation and is used mainly for grazing. (Capability unit IVe–1; windbreak suitability group 1)

Waukon clay loam, 2 to 6 percent slopes, eroded (WdB2).—This soil is in the nearly level to undulating areas in the morainic belt that crosses the central part of the county. Slopes are short and complex, and they range from 75 to 200 feet in length.

Included with this soil in mapping are small areas of the Langhei, Barnes, and Svea soils and an undifferentiated unit of Parnell and Flom soils. In some places small sandy or gravelly areas are also included in mapping.

On the upper part of the slopes much of the original surface layer has been eroded, and it is brownish in color. The organic-matter content and the infiltration rate have been lowered because the clayey subsoil is close to the surface. On the lower part of the slopes, where soil material has accumulated, the surface layer is generally thicker than normal.

All the common crops are grown on this soil. It is moderately well suited to well suited to crops. Soil blowing is a hazard in fields left bare during winter and spring. Water erosion is a hazard on the slopes. Management is needed to control soil erosion and maintain high levels of plant nutrients. (Capability unit IIe–1; windbreak suitability group 1)

Waukon clay loam, 6 to 12 percent slopes, eroded (WdC2).—This soil is in the rolling areas in the wooded morainic belt that crosses the central part of the county. Slopes are short and choppy, and they range from 75 to 250 feet in length.

Included with this soil in mapping are small areas of the Langhei, Barnes, and Svea soils and an undifferentiated unit of Parnell and Flom soils. In many places small sandy or gravelly areas are also included in mapping.

The upper part of the slopes has a brownish-colored surface layer because part of the plow layer has been mixed with the subsoil. The organic-matter content and infiltration rate have been lowered because erosion has exposed part of the clayey subsoil. On the lower parts of the slopes, where soil material has accumulated, the surface layer is thicker.

All the common crops are grown on this soil, but water erosion is a severe hazard. Soil blowing is a hazard in fields left unprotected during spring and winter. Management is needed to control soil erosion and maintain high levels of organic matter and plant nutrients. (Capability unit IIIe–1; windbreak suitability group 1)

Webster Series

The Webster series consists of deep, poorly drained soils that have developed in calcareous glacial till. These soils occur as broad, level areas of the ground moraine in the eastern part of the county.

In a representative profile, the surface layer is about 18 inches thick. In the upper 12 inches, it is neutral, black loam or clay loam. The lower part is very dark gray clay loam. The subsoil is calcareous, mottled, very dark grayish-brown to dark grayish-brown loam about 8 inches thick. The underlying material is calcareous, mottled, light olive-brown loam to a depth of 60 inches.

The organic-matter content and available water capacity are high, but natural fertility is only moderate because the high lime content causes an imbalance of plant nutrients. Permeability is moderately slow. These soils are farmed mainly to corn and soybeans. Drainage is the major concern in managing these soils.

Following is a representative profile of Webster loam, located 430 feet north and 25 feet west of the SE. corner of sec. 36, T. 126 N., R. 36 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—8 to 12 inches, black (10YR 2/1) clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A13—12 to 14 inches, very dark gray (10YR 3/1) clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A3—14 to 18 inches, very dark gray (2.5Y 3/1) clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—18 to 20 inches, very dark grayish-brown (2.5Y 3/2) loam; few, fine, faint, olive-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, irregular boundary.

B22—20 to 26 inches, dark grayish-brown (2.5Y 4/2) loam; few, fine, faint, olive-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C1—26 to 34 inches, light olive-brown (2.5Y 5/3) loam; common, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2—34 to 60 inches, light olive-brown (2.5Y 5/3) loam; common, medium, distinct, grayish-brown and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 14 to 22 inches in thickness. It is loam, clay loam, and silty clay loam in texture. The C horizon is loam and clay loam. Depth to free lime ranges from 16 to 24 inches.

The Webster soils are noncalcareous to a depth of 16 inches or more, whereas the Canisteo and Vallers soils are calcareous throughout. They have a finer textured C horizon than the Mayer soils.

Webster loam (0 to 2 percent slopes) (We).—This soil occurs closely with the Nicollet, Canisteo, and Glencoe soils. Small areas of these soils are included with this soil in mapping. In places free lime is within 12 inches of the surface or may be leached below a depth of 24 inches.

This soil has a high water table early in the year, and this limits the zone of root development. However, most areas of this soil have been drained by surface ditches, and they are farmed mainly to corn and soybeans. Tile drains are needed to insure adequate drainage. Soil blowing is a hazard in fields left bare during winter and spring. Management is needed to control erosion, to provide adequate drainage, and to maintain a high content of plant nutrients. (Capability unit IIw–1; windbreak suitability group 3)

Winger Series

The Winger series consists of deep, poorly drained soils that developed in calcareous, water-deposited silty material and in the underlying calcareous loam glacial till. These soils are in the level areas of the southeastern part of Hoff Township and the southern part of White Bear Lake Township.

In a representative profile, the surface layer is calcareous silty clay loam about 13 inches thick. It is black in the upper 7 inches and very dark gray in the lower part. The upper 13 inches of the underlying material is strongly calcareous, dark-gray to olive-gray silty clay loam. The lower part of the underlying material is calcareous, mottled, light olive-brown loam to a depth of 60 inches.

The organic-matter content and available water capacity are high, but natural fertility is only moderate because the high lime content causes an imbalance of plant nutrients. Permeability is moderately slow. The Winger soils have a high water table early in the year, and this limits the zone of root development. These soils are well suited to crops if proper soil management is practiced.

Following is a representative profile of a cultivated Winger silty clay loam, located in a level field, 900 feet west of the NE. corner of the SE¼ sec. 23, T. 123 N., R. 40 W.:

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy, breaking to weak, fine, subangular blocky structure; friable; calcareous; abrupt, clear boundary.

A12—7 to 13 inches, very dark gray (2.5Y 3/1) silty clay loam; weak, fine, subangular blocky structure; calcareous; gradual, wavy boundary.

C1ca—13 to 18 inches, dark-gray (5Y 4/1) silty clay loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2ca—18 to 26 inches, olive-gray (5Y 5/2) silty clay loam; few, fine, faint, olive mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C3—26 to 33 inches, light olive-brown (2.5Y 5/3) silt loam; common, fine, distinct, grayish-brown and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

IIC4—33 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, fine, distinct, yellowish-brown and grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 10 to 18 inches in thickness. It is silt loam or silty clay loam in texture. Depth to glacial till ranges from 18 to 40 inches.

The Winger soils developed in silty material overlying glacial till, whereas the Vallers soils developed entirely in glacial till. Unlike the Colvin soils, they have a loam-textured IIC horizon.

Winger silty clay loam (0 to 2 percent slopes) (Wn).—This soil is in the nearly level and slightly depressional level areas. Soil areas are generally broad, but in places they occur as elongated waterways.

This soil occurs closely with the McIntosh, Colvin, Vallers, and Colvin, depressional, soils. Small areas of these soils are included with this soil in mapping. Small stones and pebbles generally are on the surface. In some places the surface layer is noncalcareous in the upper few inches.

This poorly drained soil has a high water table and needs additional drainage. Most areas have been drained by surface ditches, which are adequate for most areas. Soil blowing is a hazard in unprotected fields during winter and spring.

This soil is farmed intensively to corn and soybeans. Management is needed to control soil erosion, to maintain good soil tilth, and to provide a high level of plant nutrients. Applications of nitrogen, phosphorus, and potassium are also needed. (Capability unit IIw–2; windbreak suitability group 4)

Use and Management of the Soils

This section gives interpretations of the soils for use in production of crops and pasture and in the management of field and farmstead windbreaks. It also discusses use of the soils for wildlife and recreation and in various kinds of engineering works.

Use of Soils for Crops and Pasture

This subsection discusses the capability classification of soils that is used by the Soil Conservation Service and describes the capability units in which the soils are placed. It also gives predictions of the yields to be expected when the different soils are used for crops and for pasture.

Most of the farmland in the county is used for production of corn, soybeans, oats, wheat, barley, and alfalfa. The soils range in productivity from marginal to high. Production can be increased from medium to high on many of the soils by use of good management.

The sloping soils in the county are subject to water erosion. Use of terraces, contour farming, minimum tillage, and stripcropping reduces runoff and helps to control erosion. Return of crop residue increases the infiltration rate, which increases the amount of water available for plant growth.

Soil blowing occurs throughout the county but is most severe on the outwash soils in its eastern and southwestern parts. Use of wind stripcropping, field shelterbelts, crop residue management, minimum tillage, and stubble mulching helps to control soil blowing. Most soil blowing occurs where the fields are left bare in winter and spring; therefore, fields plowed in fall should be left rough so that crop residue is exposed and the soil is protected. Fall plowing is more suitable than spring plowing on the poorly drained soils because they are difficult to work when they are wet in spring.

Artificial drainage is needed if the wet, level or depressional areas are farmed. Open ditches are commonly used to remove surface water from low areas and closed depressions and to provide outlets for tile drainage systems. Tile drainage systems can be installed in most of the soils.

Crops grown on most of the soils in the county respond to the application of fertilizer. The soils are generally low in content of phosphorus, especially those soils that have a strongly calcareous surface layer. The need for fertilizer depends on the kind of soil, on past and present management, and on the crop that is grown. Soil tests will provide part of the information that is needed to choose the best kinds and amounts of fertilizer.

Moisture deficiencies occur in most years on the well-drained and excessively drained soils of Pope County. Irrigation is practiced on the somewhat excessively drained Estherville soils (fig. 4), and it is anticipated that irrigation will be used more extensively in the county in the future. Use of irrigation will make it practicable to grow a greater variety of crops, especially on soils that have low available water capacity and otherwise are best suited to early maturing crops. Crop yields can be stabilized on the deep, well-drained soils by use of irrigation during the dry periods that occur in most years.

Most of the soils in outwash areas are suited to irrigation. Although outwash areas are underlain by a water supply,

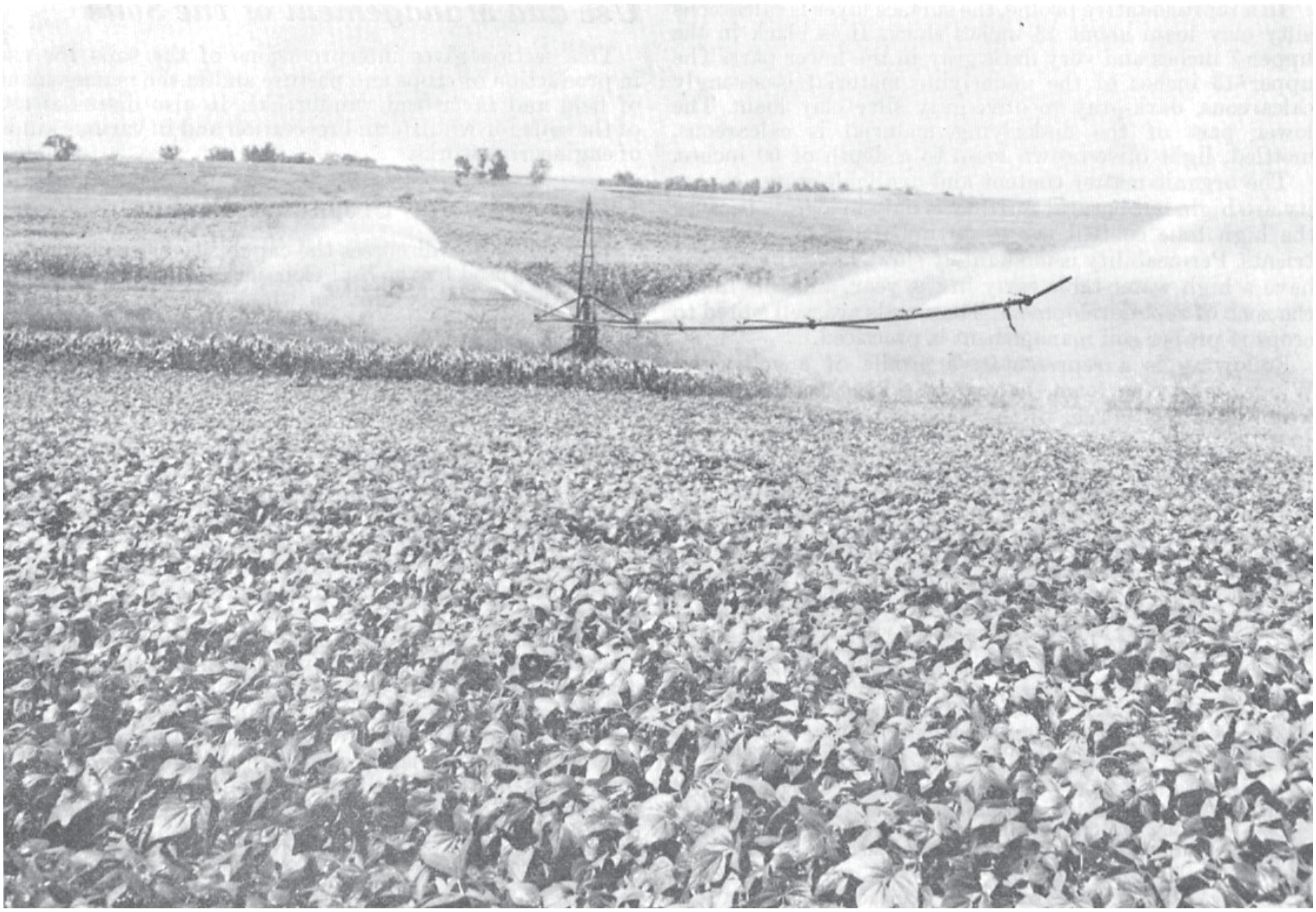

Figure 4.—**Irrigation of snap beans growing on Estherville loam.**

the amount of water needed for irrigation may not always be available. Test-well borings therefore are needed to determine the adequacy of the water supply. Two large outwash areas are located in Pope County. These are the Estherville-Muck association, in the eastern part of the county, and the Renshaw-Estelline association, in the southwestern part. The total area of these two associations is about 130,000 acres.

On the sloping soils in the outwash areas, it is difficult to assure proper distribution of irrigation water and erosion is a hazard. The choice of a proper irrigation system can minimize the disadvantages of irrigating sloping land. The problems of irrigating sloping soils must be weighed against the anticipated increase in crop yields.

Irrigation farming often requires that large fields be planted entirely to one crop. These fields are often left unprotected for long periods and are therefore very susceptible to soil blowing. Soil blowing on these fields can be controlled by practices such as planting winter cover crops of rye or oats or by establishing field windbreaks of small trees or shrubs.

Information on yields of crops grown under irrigation in Pope County is limited. Yield data gathered from field observations and trial plots, however, indicate that yields of 130 bushels of corn per acre or 8,000 pounds of snap beans per acre can be attained under a high level of irrigation management.

About 14 percent of the acreage in Pope County is used for pasture, and Kentucky bluegrass is the main grass species growing on this acreage. Other forage species that are found in association with bluegrass are redtop, timothy, white clover, quackgrass, and various annual and perennial weeds. About 8 percent of the Kentucky bluegrass pasture has been improved by use of fertilizer and controlled grazing, and another 10 percent has been fertilized and reseeded to productive adapted species such as bromegrass, alfalfa, birdsfoot trefoil, and reed canarygrass. The grasses can be planted in pure stands, but bromegrass generally is seeded in combination with a legume.

Most pastures in Pope County are grazed too closely at times during the grazing season. This decreases the vigor and productivity of the forage and increases water loss and hazard of erosion.

The management of pastureland requires attention to the stocking rate in accordance with the amount of forage produced on different soils. The management of grazing, or grazing the various species at their proper height, is necessary with all forage species and on all soils. Other measures for the management of pasture include use of fertilizer, control of weeds and brush, clipping to encourage uniform regrowth, development of watering facilities, placing salt where it will encourage uniform grazing, and reseeding to more productive species.

Bromegrass, bluegrass, and alfalfa are well suited to medium-textured soils such as those of the Barnes, Bearden, and Svea series. Alfalfa stands, however, thin out after a few years. To maintain high production of alfalfa-grass mixtures, it may be necessary to reseed the alfalfa periodically or to fertilize the grass after alfalfa disappears.

Reed canarygrass, Garrison creeping foxtail, meadow foxtail, and meadow fescue are suited to wet, poorly drained soils such as those of the Oldham, Parnell, and Arveson series. Where these soils are partially drained, birdsfoot trefoil is well suited.

Bromegrass or a mixture of bromegrass and alfalfa is suited to moderately well drained and well drained, moderately sandy and sandy soils such as those of the Hecla and Maddock series.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or engineering.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife. (None in Pope County)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in Pope County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-4 or IIIe-3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

Management by capability units

The capability units in which the soils of Pope County have been placed are discussed in the following pages. All of the soils in one unit need about the same kind of management, respond to management in about the same way, and have essentially the same limitations.

The names of the soil series represented are mentioned in the description of each capability unit, but the listing of the series names does not necessarily indicate that all of the soils of a series are in the same capability unit. To find the capability classification of any given soil, refer to the "Guide to Mapping Units."

CAPABILITY UNIT I-1

This unit consists of soils of the Barnes, Darnen, Doland, Nicollet, Svea, Tara, and Waukon series. These are well drained and moderately well drained soils having slopes of 0 to 4 percent. They are loam or silt loam throughout the profile and have a root zone that extends to a depth of more than 60 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content and nutrient supplying capacity are high. Available water capacity is high.

These soils are well suited to all crops commonly grown in the county and are farmed intensively. Corn is the main crop. These soils are also suited to grasses and trees and to the development of wildlife habitat.

These soils can be farmed intensively to row crops. Return of crop residue helps to maintain organic-matter content and to keep good soil tilth. The soils in this unit are subject to slight soil blowing when the fields are left unprotected in winter and spring. They are often plowed in fall. When plowing is left rough, the furrows help to control soil blowing, catch snow in winter and spring, and let the soil warm up faster in spring. Use of field windbreaks is also an effective means of catching snow and controlling soil blowing.

Crops respond to application of nitrogen and phosphorus.

CAPABILITY UNIT IIe–1

This unit consists mainly of soils of the Barnes, Clarion, Doland, Forman, Langhei, Nutley, Renshaw, Svea, and Waukon series. These are well drained and moderately well drained soils having slopes of 2 to 6 percent. They are loam, silt loam, or clay loam in texture, are more than 60 inches deep, and have an unrestricted root zone. Included in this unit are 700 acres of Barnes-Langhei-Renshaw soils that include small areas of droughty soils not covered in this discussion.

These soils are easily tilled and readily permeable to roots, air, and water. The Nutley soils, however, are heavy clay loam to a depth of more than 60 inches. They are very slowly permeable and are more easily compacted than the other soils. All of these soils have high organic-matter content and nutrient supplying capacity. Available water capacity is high.

These soils are farmed intensively. Corn is the main crop, but soybeans and small grains are well suited. These soils are also well suited to legumes, grasses, and trees and to the development of wildlife habitat.

The main limitation to farming these soils is erosion. Erosion generally occurs late in spring when the soils are not protected from the rain. Soil blowing may occur on unprotected fields in winter and spring.

Row crops can be grown intensively on these soils under a high level of management. Return of crop residue helps to maintain the organic-matter content and to keep good soil tilth. These soils are often plowed in fall. When the plowing is left rough, the furrows help to control soil blowing and catch snow in winter. Soil and water losses because of runoff are reduced by keeping good tilth in the plow layer. Minimum tillage and stubble mulching help to keep the soil permeable to water. Use of terracing, contour tillage, and sodded waterways (fig. 5) should be considered where slopes are suitable.

Crops respond to application of nitrogen and phosphorus. Supply of phosphorus is generally deficient because the high pH of the subsoil limits the amount that is available. Availability of phosphorus and potassium is generally low where the soils are light in color and are calcareous.

CAPABILITY UNIT IIe–2

This unit consists of Langhei-Barnes loams, 2 to 6 percent slopes, eroded. These are somewhat excessively drained and well-drained, slightly eroded and moderately eroded soils. They are loam in texture, are more than 60 inches deep, and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots and air. The Langhei soil is slowly permeable to water in the surface layer, because the high concentration of lime and erosion of the surface soil results in poor soil structure. Organic-matter content and nutrient supplying capacity are low in the Langhei soil, and high in the Barnes soil, because of the high lime content of the soil. Available water capacity is high. In most places the thin surface layer has eroded from the upper part of the slope or has been mixed with the subsoil through plowing, thus forming a highly calcareous plow layer.

These soils are farmed intensively. Corn, soybeans, and oats are the main crops. These soils are also suited to grasses, legumes, and trees and to the development of wildlife habitat.

Erosion is the main limitation to farming. Erosion ordinarily occurs late in spring, when the soils are not protected from heavy rains. Soil blowing occurs on bare fields in winter and spring.

When erosion control practices such as use of terraces or contour farming are applied, the cropping system can be more intensive. Crop production is generally lower on the eroded slopes because the organic-matter content is lower and the lime content is high. Application of manure and fertilizer to these areas increases production. Sodded waterways are needed wherever runoff collects or as outlets for terraces or diversions.

Return of crop residue helps to maintain organic-matter content and to keep good soil tilth. These soils are often plowed in fall. Leaving the plowing rough helps to control soil blowing and catches snow in winter. Use of minimum tillage and stubble mulching helps to keep the soil permeable, and thus reduces the loss of moisture through runoff.

Crops respond well to application of nitrogen and phosphorus. The supply of phosphorus and potassium is generally low in the eroded areas.

CAPABILITY UNIT IIe–3

This unit consists of soils of the Estherville, Flandreau, and Fordville series. These are well-drained and somewhat excessively drained soils having slopes of 2 to 6 percent. They consist of loam and silt loam underlain by sand or gravel at a depth of 24 to 40 inches.

These soils are easily tilled and readily permeable to roots, air, and water. Organic-matter content is high, but nutrient supplying capacity is only moderate because of the limited root zone. Available water capacity is moderate. Hazard of erosion is moderate, especially late in spring. Droughtiness can occur during prolonged dry periods.

Corn, soybeans, and oats are the main crops. These soils are also suited to legumes, grasses, and trees and to the development of wildlife habitat.

These soils can be farmed intensively if soil blowing and water erosion are controlled. Soil blowing is a hazard on fields left bare in winter and spring. Return of crop residue

Figure 5.—**Sodded waterway on Barnes-Langhei loams, 2 to 6 percent slopes, eroded.**

helps to maintain organic-matter content and to keep good soil tilth. These soils are generally plowed in fall after a small grain crop has been harvested. Leaving the plowing rough helps to control erosion and catches snow in winter and spring. Use of minimum tillage and stubble mulching helps to keep the soils permeable and to reduce runoff. Terracing and contour farming are erosion control practices that can be used on suitable slopes. Sodded waterways are needed wherever water collects and causes washing.

These soils respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIe-4

This unit consists of soils of the Bearden, Hamerly, and McIntosh series. These are moderately well drained and somewhat poorly drained, slightly eroded soils having slopes of 0 to 4 percent. They are loam or silt loam in texture, are more than 60 inches deep, and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots and air. The surface layer is only slowly permeable, because the concentration of lime results in poor soil structure. Organic-matter content is high, but nutrient supplying capacity is only moderate because the lime content is high. Available water capacity is high.

These soils are farmed intensively. Corn is the main crop, but soybeans, oats, wheat, barley, and flax are also well suited. These soils are also suited to legumes, grasses, and trees and to the development of wildlife habitat. Crops respond well to application of nitrogen and phosphorus.

The main limitation to farming is the degree of fertility relative to the high lime content. The high pH of these soils reduces the availability of phosphorus. The supply of potassium is generally inadequate for plant growth because it cannot compete with the excessive amount of lime. The high lime content also causes the soil granules to break down into smaller particles that are easily blown by the wind.

Soil blowing is a problem on fields left bare in winter and spring. These soils are commonly plowed in fall and left rough. This reduces soil blowing in winter and spring, catches snow, and allows the cloddy soil to mellow from the freezing and thawing that occur in winter. Use of field windbreaks also helps to control soil blowing.

Return of crop residue helps to maintain the organic-matter content and to keep good tilth. Use of minimum tillage and stubble mulching helps to keep the soil permeable. Terracing, contour tillage, and stripcropping should be considered where the slopes are suitable.

CAPABILITY UNIT IIs-1

This unit consists of soils of the Estelline, Estherville, Flandreau, Fordville, and Wadena series. These are well-drained and somewhat excessively drained soils having slopes of 0 to 3 percent. They are loam or silt loam in texture and are underlain by sand and gravel at a depth of 24 to 40 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is high, but nutrient supplying capacity is only moderate because the root zone is restricted. Available water capacity is moderate.

These soils are farmed intensively. Corn is the main crop, but soybeans and small grains are well suited. These soils are also well suited to legumes, grasses, and trees and to the development of wildlife habitat.

If these soils are farmed under a medium level of management, a cropping system including a green-manure crop that is plowed under every 3 years is adequate. Under a high level of management, row crops can be grown year after year.

Soil blowing can be a problem on fields left bare in winter and spring. These soils can be plowed in spring. Fields that are plowed in fall after the spring grain crop has been harvested generally are left rough to help control soil blowing in winter and spring. Use of stubble mulching and field windbreaks help to control soil blowing.

Droughtiness can occur during prolonged dry periods, and the amount of moisture that can be held normally is not adequate for good crop growth. These soils, however, are well suited to irrigation. Waterways crossing these soils should be sodded in order to prevent the water from cutting into the coarse-textured substratum.

These soils respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIw-1

This unit consists of soils of the Flom, Parnell, Perella, and Webster series. These are poorly drained and very poorly drained, slightly depressional to very gently sloping soils. They are silt loam or silty clay loam in texture and are more than 60 inches deep. The thickness of the root zone is determined by the depth to the water table. The water table is often within 3 feet of the surface in spring.

Both internal and surface drainage are restricted. Permeability is moderately slow. Organic-matter content and nutrient supplying capacity are high. Available water capacity is high.

These soils are farmed intensively. Corn is the main crop, but soybeans, small grains, and legumes are well suited. If these soils are adequately drained and fertilized and all crop residue is returned, they can be farmed to row crops year after year. They are also suitable for the planting of trees and for the development of wildlife habitat.

Wetness is the main limitation to farming. Sometimes these soils are ponded for a few days because of the moderately slow permeability. If tilled when wet, they become compacted and less permeable to roots and moisture.

Most areas of these soils have been drained by surface ditches (fig. 6). Although this removes the surface water early in the season, there is still a 20-percent probability of a partial crop failure. Tile drainage is needed to provide adequate subsurface drainage, which lowers the water table and provides an optimum root zone.

Water from the surrounding sloping land often collects and runs across these soils in drainageways. These drainageways should be shaped and sodded to prevent gullies from forming.

Soil blowing is a problem on fields left bare in winter and spring. These soils generally are plowed in fall. Fall plowing makes it unnecessary to work the fields when they are too wet in spring and allows the cloddy soil to mellow from freezing and thawing in winter. Leaving the plowing rough, so crop residue is exposed, helps to control soil blowing. Use of minimum tillage and proper timing of field operations help to prevent soil compaction. Growing a green-manure crop or occasionally a deep-rooted legume helps to keep good tilth and to maintain subsoil permeability.

Crops respond well to application of nitrogen and phosphorus. It is important that starter fertilizer be applied. These soils are slow to warm up in spring, and plant nutrients are not always available to young plants.

CAPABILITY UNIT IIw-2

This unit consists of soils of the Canisteo, Colvin, Lamoure, Vallers, and Winger series. These are somewhat poorly drained and poorly drained, calcareous, level soils. They are loam to silty clay loam in texture and are more than 60 inches deep. Thickness of the root zone is limited by depth to the water table. In spring the water table is within 2 feet of the surface.

Organic-matter content is high, but nutrient supplying capacity is only moderate because lime content is high. Available water capacity is high. Both internal and surface drainage are slow, and permeability is moderate to moderately slow.

If adequately drained, these soils are farmed intensively. Corn is the most common crop, but soybeans, small grains, and legumes are well suited. These soils are also well suited to grasses and trees and to the development of wildlife habitat.

If these soils are given a high level of management, including use of proper fertilization, return of crop residue, and minimum tillage, they can be farmed to row crops year after year.

Wetness is the main limitation to farming. Water is often ponded on the surface for several days in spring and during heavy rains. If tilled when wet, these soils become compacted and more impermeable to roots, air, and water. Drainage through open ditches removes the surface water early and makes cropping practical. Partial crop failure, however, can be expected 20 percent of the time. Tile drainage is needed to provide optimum soil drainage, to lower the water table, and to provide an adequate root zone.

Use of minimum tillage and the proper timing of field operations are important to help prevent soil compaction. Growing an occasional green-manure crop or a deep-rooted legume helps to keep good soil tilth and to keep the subsoil permeable.

These soils generally are plowed in fall, because they are too wet in spring. This allows the cloddy soil to mellow from the freezing and thawing that take place in winter.

Figure 6.—**Shallow ditch on Parnell and Flom silty clay loams.**

Leaving the plowing rough, with much crop residue remaining on the surface, helps to reduce soil blowing. Use of stubble mulching and field windbreaks also helps to reduce soil blowing. Drainageways should be sodded where there is a hazard of gullying.

These soils all have high lime content. Special attention should be given to the level of available phosphorus and potassium.

CAPABILITY UNIT IIw-3

This unit consists of soils of the Marysland and Mayer series. These are poorly drained, level or slightly depressional soils that formed in calcareous loam underlain by sand or gravel at a depth of 24 to 40 inches. Thickness of the root zone is determined by depth to the water table. In spring the water table is often within 2 feet of the surface.

Organic-matter content is high, but nutrient supplying capacity is only moderate because the root zone is restricted. Available water capacity is moderate.

Where these soils are adequately drained, they are farmed intensively. Corn is the main crop, but soybeans, oats, grasses, and legumes are also commonly grown.

Wetness is the main limitation to farming. If these soils are tilled when wet, they become compacted and impermeable to water. Soil blowing is a hazard on fields left bare in winter and spring.

Most of these soils have been drained by surface ditches. Use of tile drainage is difficult because the substratum is coarse textured. Sloughing and caving in are constant hazards during installation of tile, and plugging with sand is a hazard after tile has been installed. If water from the surrounding slopes runs across these soils, the waterways should be shaped and sodded to prevent water from cutting into the coarse-textured substratum.

These soils generally are plowed in fall. This eliminates working the fields when they are too wet in spring and also allows the cloddy soil to mellow from freezing and thawing in winter. Leaving the fall-plowed surface rough, so that crop residue is exposed, helps to reduce soil blowing. Use of stubble mulching and field windbreaks is also an effective means of controlling soil blowing.

Return of crop residue helps to keep good soil tilth. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. Under a medium level of management, in which minimum tillage is practiced, crop residue is returned, and adequate fertilizer is applied, a cropping system that includes a green-manure crop every 4 years is adequate. Under a high level of management, these soils can be farmed to row crops year after year.

Special attention should be given to the phosphorus content of these soils, since the high pH keeps the availability of phosphorus at a low level. The Marysland soils are particularly high in content of lime just below the surface layer. Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIIe-1

This unit consists of soils of the Barnes, Langhei, Clarrion, Forman, and Waukon series. These are well-drained and somewhat excessively drained, rolling, slightly eroded to moderately eroded soils having slopes of 6 to 12 percent. They are loam or clay loam in texture and are more than 60 inches deep.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is low to high, nutrient supplying capacity is low to high, and available water capacity is high.

These soils are farmed intensively. Corn, soybeans, small grains, and legumes are the main crops. Crop production generally is lower on the eroded slopes, because organic-matter content is lower and the lime content is high. These soils are also well suited to grasses and trees and to the development of wildlife habitat.

The main limitation to farming these soils is erosion (fig. 7). Erosion generally occurs in spring when the fields are not protected from heavy rains. Many areas are eroded, and the organic-matter content and water infiltration rate have been lowered. Soil blowing occurs on the hilltops in winter and spring. Water tends to run off rather than to soak into the soil because the slope is so steep. Therefore, these soils are seldom fully charged with water, and they often dry out late in summer.

Use of contour stripcropping and terraces on slopes that are suitable (fig. 8) helps to control erosion and to conserve moisture. Sodded waterways are needed wherever runoff collects or as outlets from terraces or diversions. Use of minimum tillage and stubble mulching helps to keep the soil permeable and to reduce loss of moisture through runoff.

A medium level of management that includes use of contour stripcropping, proper fertilization, return of all crop residue, and a cropping system including 2 years of hay in 5 helps to control soil blowing. Cropping can be more intensive if the fields are terraced and wheel track planting

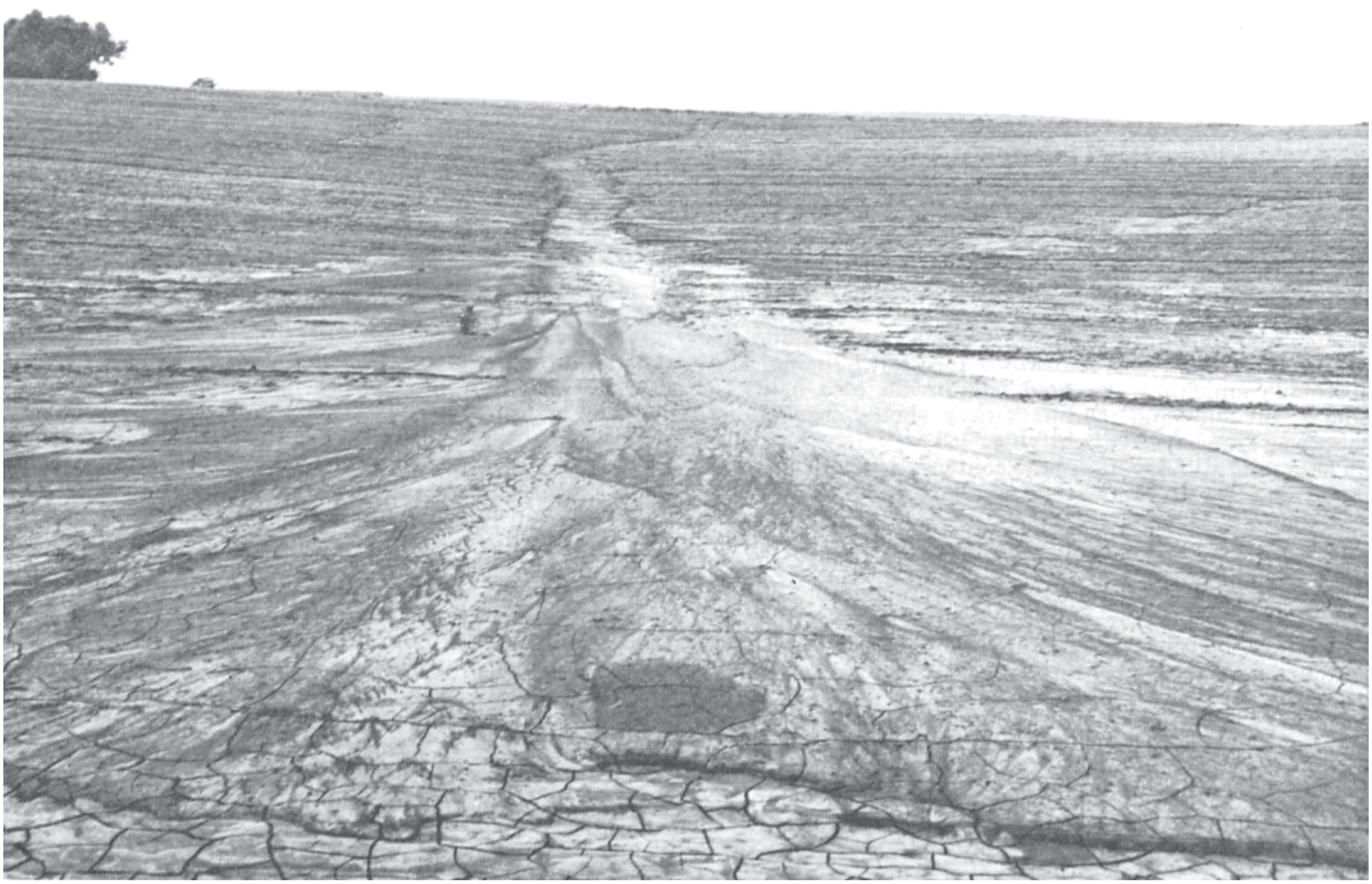

Figure 7.—**Erosion on Barnes-Langhei loams, 6 to 12 percent slopes, eroded.**

Figure 8.—Contour stripcropping on Barnes-Langhei loams, 6 to 12 percent slopes, eroded.

is practiced. These soils are generally plowed in fall and left rough in order to reduce soil blowing and to catch snow.

Crops respond well to application of nitrogen and phosphorus. The availability of phosphorus and potassium is generally low in the eroded areas.

CAPABILITY UNIT IIIe–2

This unit consists of Langhei-Barnes loams, 6 to 12 percent slopes, eroded. These are somewhat excessively drained and well-drained rolling, slightly eroded to moderately eroded soils. They are loam in texture, are more than 60 inches deep, and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots, air, and water. Nutrient supplying capacity is low in the Langhei soil and high in the Barnes soil. Available water capacity is high. Infiltration rate is slow in the Langhei soil because the organic-matter content is low and the lime content is high. This condition results in poor structure in the surface layer. Rainfall tends to run off rather than to soak into these soils because of the slope and the low infiltration rate. These soils are seldom fully charged with water and often are droughty by late in summer.

These soils are farmed intensively. Corn, soybeans, small grains, legumes, and grasses are the main crops. These soils are also suited to trees and to the development of wildlife habitat. Crop production is generally lower on the eroded slopes because of the lower organic-matter content and the high lime content.

Erosion is a severe hazard, particularly late in spring when the soils are not protected from heavy rains. Soil blowing occurs on the unprotected hilltops in winter and spring. Use of contour stripcropping and terraces helps to control erosion and to conserve moisture. Use of minimum tillage and stubble mulching helps to keep the soil permeable and to reduce loss of moisture through runoff. These soils generally are plowed in fall and left rough in order to reduce soil blowing and to catch snow.

A medium level of management includes use of contour stripcropping, proper fertilization, the return of all crop residue, and a cropping system containing 2 years of hay in 5 to help control erosion. Cropping can be more intensive if the fields are protected from erosion. Sodded waterways are needed wherever runoff collects or as outlets from terraces or diversions.

Crops respond well to application of nitrogen and phosphorus. Availability of phosphorus and potassium is generally low in the eroded areas.

CAPABILITY UNIT IIIe-3

This unit consists of soils of the Estherville and Renshaw series. These are somewhat excessively drained, gently sloping to undulating soils having slopes of 2 to 6 percent. The surface layer is loam or sandy loam underlain by sand and gravel at a depth of 12 to 24 inches.

These droughty soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is moderate. Nutrient supplying capacity is low because the root zone is restricted. Available water capacity is low.

These soils are farmed intensively. Corn, soybeans, and oats are the main crops. Early maturing crops make the best use of the limited amount of available moisture. Crop production is low to moderate. These soils are also suited to grasses, legumes, and trees and to the development of wildlife habitat.

Droughtiness is the main limitation, and moisture deficiencies occur annually. Soil blowing is a problem on fields left bare in winter and spring. Erosion occurs in the more strongly sloping areas.

Return of all crop residue helps to maintain organic-matter content, to keep good soil tilth, and to provide the maximum available water capacity.

These soils generally are plowed in spring, because fall plowing exposes them to the strong winds of winter and spring. Use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks controls soil blowing and reduces the evaporation and transpiration rates of the soil and plants. Use of contour tillage reduces erosion.

The lower slopes of these soils are well suited to supplemental irrigation. Because the available water capacity is low, however, these soils must be irrigated frequently. When adequately irrigated, these soils are very well suited to field and vegetable crops.

Crops respond well to application of nitrogen and phosphorus when adequate moisture is available.

CAPABILITY UNIT IIIs-1

This unit consists of soils of the Estherville, Osakis, and Renshaw series. These are somewhat excessively drained and moderately well drained soils having slopes of 0 to 2 percent. They are loam or sandy loam in texture and are underlain by sand and gravel at a depth of 12 to 24 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is moderate to high, but nutrient supplying capacity is low because the root zone is restricted. Available water capacity is low.

These soils are best suited to early maturing crops because of the limited amount of available water. Small grains, soybeans, and corn are the main crops. Crop production is low to moderate. Hay crops produce well on the first cutting, but often the second cutting is poor. These soils are also suited to grasses, legumes, and trees and to the development of wildlife habitat.

Droughtiness is the main limitation to farming. These soils commonly are deficient of water by midsummer. Soil blowing is a hazard on fields left bare in winter and spring. These soils are generally plowed in spring, which reduces soil blowing and protects the soils in winter. Also, the stubble and stalks hold snow, which provides additional water for the soil. Use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks helps to control soil blowing and to reduce the evaporation and transpiration rates of the soil and plants. Return of crop residue helps to maintain organic-matter content, to keep good soil tilth, and to provide the maximum available water capacity.

These soils are well suited to irrigation, but because the available water capacity is low, the irrigation interval is short. When properly irrigated, high production of field and vegetable crops can be expected.

Application of the proper amount of fertilizer is important, because the root zone is restricted. Excessive fertilization can injure plants in dry years, while in wet years some fertilizer may be lost out of the root zone by leaching.

CAPABILITY UNIT IIIs-2

This unit consists of soils of the Dickinson and Sverdrup series. These are somewhat excessively drained soils having slopes of 0 to 6 percent. Their surface layer is loam or sandy loam underlain by sand at a depth of 14 to 24 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is high. Nutrient supplying capacity is low. Available water capacity is low.

These soils are farmed intensively. Corn, soybeans, and small grains are the main crops. Early maturing crops make best use of the available water. Crop production is low. These soils are also suited to legumes, grasses, and trees and to the development of wildlife habitat.

Soil blowing is a severe hazard on fields left bare in winter and spring. These soils can be plowed in spring. Fields plowed in fall should be left rough, and the crop residue exposed. The stubble left standing over winter helps to control soil blowing and to catch snow, which provides additional water for the soil. Use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks helps to control soil blowing and to reduce the evaporation and transpiration rates of the soil and plants. Erosion is a hazard where slopes are greater than 4 percent. Use of contour tillage on these slopes helps to control erosion.

These are moderately droughty soils because the substratum is sandy, and they commonly have a low moisture content by midsummer. These soils are well suited to irrigation, but because of the low available water capacity, the irrigation interval is short. When properly irrigated, high production of field or vegetable crops can be expected. Return of crop residue and plowing under a green-manure crop every 3 or 4 years help to maintain the organic-matter content, to keep good soil tilth, and to assure the maximum available water capacity.

Crops respond well to application of nitrogen and phosphorus if adequate water is available.

CAPABILITY UNIT IIIs-3

This unit consists of soils of the Clontarf and Malachy series. These are moderately well drained soils having slopes of 0 to 2 percent. They have a sandy loam surface layer underlain by sand at a depth of 16 to 30 inches. Malachy sandy loam is calcareous in the surface layer.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is high, but nutrient supplying capacity is low to moderate because of the nature of the parent material. Available water capacity is low.

These soils are farmed intensively. Corn, soybeans, and small grains are the main crops. Early maturing crops make the best use of the available water. These soils are also suited to legumes, grasses, and trees and to the development of wildlife habitat.

Soil blowing is a severe hazard in winter and spring if fields are left unprotected. Droughtiness is an annual problem, and these soils generally are deficient of water by midsummer. The soils in this unit generally are plowed in spring. Fields plowed in fall are left rough to prevent soil blowing in winter and spring. Disking these soils, rather than plowing, leaves a rough surface that protects against soil blowing. Use of stubble mulching, wind stripcropping, and field shelterbelts also helps to control soil blowing. Return of crop residue helps to maintain the organic-matter content and to keep good soil tilth.

Crops respond to application of nitrogen and phosphorus.

CAPABILITY UNIT IIIw-1

This unit consists of soils of the Glencoe, Parnell, and Tonka series. These are poorly drained and very poorly drained depressional soils. They are silt loam and silty clay loam in texture and are more than 60 inches deep. Thickness of the root zone is determined by depth to the water table. The water table generally is near the surface.

Organic matter content and nutrient supplying capacity are high. Available water capacity is high. Permeability is moderately slow to very slow. Both internal and surface drainage are restricted.

These soils need drainage before they are farmed. Where adequately drained, they are farmed intensively. Crop production is low to moderate, and probability of crop failure is about 20 percent. Corn is the main crop, but good production of sugar beets, soybeans, and small grains can be expected. Grasses and legumes grow well, and excellent wildlife habitat can be developed in undrained areas.

Most areas of these soils are drained by open ditches, which remove surface water and provide outlets for tile drainage. Shallow open ditches that drain closed depressions should be sodded where gullying is a problem. Tile drainage is needed to provide adequate internal drainage. This lowers the water table, provides an optimum root zone, and allows the soil to warm up earlier in spring.

If these soils are tilled when wet, they become compacted and less permeable to roots and moisture. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. Growing a green-manure crop, or occasionally a deep-rooted legume, helps to keep good tilth and to maintain permeability.

These soils are plowed in fall and left rough in winter and spring to prevent soil blowing. Fall plowing makes it unnecessary to work the soils in spring, when they are too wet, and allows the cloddy soil to mellow from freezing and thawing in winter. Trees normally used for field windbreaks are not well suited to these soils, because the water table is high. Under a medium level of management that includes proper fertilization and the return of crop residue, a cropping system such as 3 years of corn followed by a small grain with a green-manure crop is adequate. These soils can be cropped even more intensively if they are drained completely, kept in good tilth, and given a high level of management.

These soils are slow to warm up in spring, and nutrients are not always available to the young plants. It is therefore important to use a starter fertilizer to initiate plant growth. Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIIw-2

This unit consists of soils of the Colvin and Oldham series. These are strongly calcareous, poorly drained, level and depressional soils. They are silty clay loam in texture and are more than 60 inches deep. Thickness of the root zone is determined by depth to the water table.

Organic-matter content is high, but nutrient supplying capacity is only moderate because the pH of the soils is high. Available water capacity is high. Permeability is moderately slow. Both internal and surface drainage are restricted.

These soils are farmed intensively where they are adequately drained. Crop production is low to moderate, and the probability of crop failure is 20 percent. Corn is the main crop, but good production of soybeans and small grains can be expected. Grasses and legumes are well suited to these soils, and excellent wildlife habitat can be developed in undrained areas.

Wetness is the main limitation to farming these soils, and they must be drained before they can be cropped. Where undrained, the water table generally is near the surface. Water ponds in these undrained areas for several weeks late in spring. Most areas are drained by open ditches, which remove the surface water. Shallow ditches that drain closed depressions should be sodded where gullying is a problem. Tile drainage is needed to provide adequate internal drainage. This lowers the water table, provides an adequate root zone, and allows the soil to warm up earlier in spring.

If these soils are worked when wet, they become compacted and less permeable to roots and water. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. Growing a green-manure crop, or occasionally a deep-rooted legume, helps to keep good soil tilth and to maintain permeability.

These soils are plowed in fall and left rough over winter and spring to prevent soil blowing. This makes it unnecessary to work the soils when they are too wet in spring. It also allows the cloddy, compacted soil to mellow from freezing and thawing in winter. Trees normally used for field windbreaks are not well suited to these soils because the water table is high.

Crops respond well to application of nitrogen and phosphorus. The high content of lime in these soils keeps the availability of phosphorus at a low level. Potassium generally is not available, because the pH of these soils is high.

CAPABILITY UNIT IIIw-3

Mayer loam, depressional, is the only soil in this unit. This is a very poorly drained, calcareous soil that is underlain by sand and gravel at a depth of 24 to 40 inches. Thickness of the root zone is determined by depth to the water table.

Organic matter content is high, but nutrient supplying capacity is only moderate because the root zone is restricted. Available water capacity is moderate. Both internal and surface drainage are slow.

Wetness is the main limitation to farming this soil, and it needs to be drained before it can be farmed. In spring the water table is at the surface. Water commonly ponds on this soil for several weeks late in spring. Most areas have been drained by open ditches, which remove the surface water quickly. Use of tile drainage is difficult because the substratum is sandy. Tile lines are often plugged with sand and become useless. If tile is installed, it should be blinded to prevent plugging.

This soil is farmed intensively where it is adequately drained. Crop production is poor, and probability of crop failure is 20 percent. Because this soil is slow to warm up in spring, corn and soybeans are the main crops. Small grains and grasses are also commonly grown. Legumes and trees are not well suited, because the high water table is high. Where undrained, this soil provides excellent wildlife habitat.

This soil is too wet to be plowed in spring. If worked when wet, it becomes compacted and less permeable to roots and water. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. The fall plowing should be left rough to reduce the soil blowing that takes place in winter. This also allows the cloddy, compacted soil to mellow from the freezing and thawing that occur in winter.

Under a medium level of management that includes adequate drainage, proper fertilization, return of crop residue, and proper timing of field operations, this soil can be farmed to row crops year after year.

Special attention should be given to application of phosphorus and potassium. These nutrients generally are not available to plants, because this soil has high pH.

CAPABILITY UNIT IIIw-4

This unit consists of soils of the Arveson and Hamar series. These are poorly drained and very poorly drained, nearly level to depressional soils having slopes of 0 to 2 percent. They are sandy loam in texture and are underlain by sand or gravel at a depth of 14 to 24 inches.

Organic-matter content is high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low. Both internal and surface drainage are slow. The water table is within 2 feet of the surface in spring and generally drops to about 4 feet by August.

These soils are farmed intensively. Crop production is low to moderate, and probability of crop failure is 20 percent. Corn, soybeans, and small grains are the main crops. These soils are suited to grasses and trees and to the development of wildlife habitat.

Most areas of these soils have been drained by open ditches, which remove the surface water early in the season and make cropping practicable. This does not, however, control the water table. Use of tile drainage is risky because the coarse-textured subsoil can plug the tile. If tile is installed, it should be blinded to prevent plugging.

These soils are often plowed in fall and left rough in winter and spring to reduce soil blowing and to hold snow. Disking these soils, rather than plowing, leaves a rough surface that is resistant to soil blowing. Use of stubble mulching, wind stripcropping, and field windbreaks help to control soil blowing.

If these soils are given a medium level of management that includes adequate drainage, proper fertilization, and the return of crop residue, a cropping system that includes a green-manure crop every 3 or 4 years is adequate. Under a high level of management, they can be farmed to row crops year after year.

Crops respond well to application of nitrogen and phosphorus. The Arveson soils have a high lime content, but the level of available phosphorus and potassium generally is low.

CAPABILITY UNIT IIIw-5

This unit consists of Blue Earth silt loam; Muck; Muck, calcareous; Muck, calcareous, over loam; and Muck over loam. These, except for the Blue Earth soil, are very poorly drained organic soils that formed in shallow lakes and large depressions. The surface layer is peat or muck, 12 to 72 inches thick, underlain by loamy soil material. The Blue Earth soils formed in silty sediments. The thickness of the root zone is determined by depth to the water table. Where undrained, the water table is near the surface.

Organic-matter content is high or very high, but nutrient supplying capacity is low to moderate because of the nature of the parent material. Available water capacity is high. Both internal and surface drainage are restricted.

Wetness is the main problem in management. Ponding commonly occurs for several weeks late in spring and early in summer. Most of these soils have not been drained and are under a cover of marsh grass. These areas are wet throughout the year, and water 1 to 2 feet deep often stands on the surface.

Some areas of these soils have been drained by surface ditches, which remove the surface water and permit cropping. If the ditches are not deep enough or spaced closely enough, however, the water table is not adequately lowered. The soils remain cold and wet in spring. Where tile is installed, it should be placed 48 inches deep, preferably in the loamy material.

These soils are farmed intensively where adequately drained. However, these soils are slow to warm up in spring, and late and early frosts and floods are annual problems. Corn and soybeans are the main crops. Field corn is occasionally grown but often does not mature. When small grains are planted, production is high but the grain often lodges and is not harvestable. Corn for silage grows well. Grasses are well suited, and these soils provide excellent pasture where drained. They can be developed into excellent wildlife habitat. These soils are not well suited to trees.

Crop residue should be returned to keep good tilth. These soils are susceptible to soil blowing because they are light and fine textured. Soil blowing can be controlled by use of cover crops, rough tillage, and field windbreaks.

Crops respond well to application of a balanced fertilizer. These soils contain an adequate amount of calcium but generally are low in content of phosphorus and potassium. They are generally calcareous, but Muck and Muck over loam are noncalcareous.

CAPABILITY UNIT IVe-1

This unit consists of soils of the Barnes, Clarion, Langhei, Renshaw, Storden, and Waukon series. These are well-drained and somewhat excessively drained, slightly eroded and moderately eroded soils having slopes of 12 to 25 percent in most areas. Soils of the Barnes-Langhei-Renshaw complex have slopes of 6 to 12 percent. They are loam in texture and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots, air, and water. Available water capacity is high. The Barnes and Waukon soils have high organic-matter content and nutrient supplying capacity. The Langhei and Storden soils have low to moderate organic-matter content and nutrient supplying capacity. Infiltration rate is slow, because the lime content is high and the surface layer is eroded. In many areas the surface layer of the soils in this unit has been eroded, and the subsoil is exposed.

Most areas of these soils are cropped. Corn, soybeans, and small grains are the main crops. These soils are well suited to legumes, grasses, and trees and to the development of wildlife habitat. Crop production is generally low, but production of grasses and legumes is medium. About 1,200 acres of the Waukon soil is wooded.

Erosion is a very severe limitation to farming. Erosion generally occurs in spring, when the soils are not protected from the rains. Much of the rain that falls on these soils runs off. These soils therefore are seldom fully charged with water, and plants often suffer from lack of moisture. Droughtiness is often a problem late in July or in August. Use of stubble mulching, mulch planting, minimum tillage, cropping systems, and stripcropping helps to control erosion and to conserve moisture. Use of contour tillage is difficult because the slopes are short, irregular, and steep, but its use should be considered where the slopes are suitable. Sodded waterways are needed wherever water collects and presents a hazard of gullying.

Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IVe-2

This unit consists of soils of the Estherville, Renshaw, and Sverdrup series. These are mainly somewhat excessively drained soils. Slopes range from 6 to 12 percent. These soils consist of loam or sandy loam underlain by sand and gravel at a depth of 12 to 24 inches.

These droughty soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because the root zone is limited. Available water capacity is low.

Small grains, soybeans, and corn are the main crops. Crop production is low. These soils are best suited to the earlier maturing crops because the available water capacity is limited. Production of hay at the first cutting is good, but the second cutting generally is very poor. These soils are suited to grasses and trees and to the development of wildlife habitat.

Droughtiness and erosion are the main problems in management. These soils are commonly droughty by midsummer. Soil blowing is a problem on fields left bare early in spring. These soils can be plowed in spring. When they are plowed in fall, however, they generally are left rough to reduce soil blowing and erosion.

These soils are subject to erosion, and contour farming should be used where practicable. If these soils must be farmed up and down the slope, row crops should not be grown because there is an erosion hazard. Use of terraces on these soils is not suitable because it exposes the coarse-textured substratum.

Return of crop residue and plowing under green manure help to maintain the organic-matter content, to keep good soil tilth, and to insure the maximum available water capacity. Use of stubble mulching and minimum tillage help to control erosion and to keep good tilth. Sodded waterways should be established where water collects and runoff occurs.

Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IVs-1

This unit consists of soils of the Hecla and Maddock series. These are moderately well drained and well drained droughty soils having slopes of 0 to 6 percent. The surface layer is loamy sand and sandy loam underlain by fine sand and medium sand that provide an unrestricted root zone.

These soils are easily tilled and are permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is very low.

These soils generally are farmed. Corn, soybeans, and small grains are the main crops. Early maturing crops make the best use of the limited moisture supply. These soils are suited to grasses, legumes, and trees, and to the development of wildlife habitat.

Droughtiness is a severe limitation, and the soils generally are deficient of moisture by mid July. Soil blowing is a severe hazard on these soils when they are left bare in winter and spring. Fields generally are plowed in spring in order to protect them from soil blowing in winter and spring. Use of stubble mulching, cropping systems, minimum tillage, wind stripcropping, and field windbreaks helps to control erosion and to conserve soil moisture. Return of all crop residue and plowing under a green-manure crop every 3 or 4 years help to maintain the organic-matter content and to keep good soil tilth.

Crops respond well to application of nitrogen, phosphorus, and potassium.

CAPABILITY UNIT IVs-2

This unit consists of soils of the Salida and Sioux series. These are excessively drained soils having slopes of 0 to 12 percent. They consist of sandy loam, less than 12 inches deep, underlain by sand and gravel.

These soils are rapidly permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is very low.

These soils generally are farmed. Corn, soybeans, small grains, and legumes are the main crops. Early maturing crops make the best use of the limited moisture supply. Production of all crops is so low that these soils are best used as grassland. These soils are suited to grasses and trees and to the development of wildlife habitat.

Droughtiness and low fertility are severe hazards to farming of these soils (fig. 9), because their root zone is so thin. The supply of available nutrients and moisture is depleted by late in June. Erosion is a problem on the more rolling slopes if they are left bare. Use of stubble mulching, minimum tillage, stripcropping, and field windbreaks

Figure 9.—**Corn damaged by drought on Salida sandy loam, 0 to 6 percent slopes.**

helps to control erosion and to conserve soil moisture. Return of crop residue helps to maintain organic-matter content and to keep soil tilth.

Crops respond to application of nitrogen, phosphorus, and potassium.

CAPABILITY UNIT IVw-1

This unit consists of Muck, calcareous, over sand, and of Muck over sand. These are very poorly drained organic soils that formed in shallow lakes. The surface layer is muck underlain by sand at a depth of 12 to 40 inches. Thickness of the root zone is determined by depth to the water table.

Organic-matter content is very high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is high.

Corn and soybeans are the main crops. These soils are slow to warm up in spring, and late and early frosts and flooding are annual hazards. When small grains are planted, production is high but the grain often lodges and is not harvestable. Production of corn for silage is high, but corn for grain does not often mature. Grasses grow well on these soils when they are drained, and they are excellent as pasture. These soils provide excellent wildlife habitat. They give cover for pheasant and deer, and the ponded areas provide resting and nesting areas for ducks.

Most areas of these soils do not have sufficient natural drainage to be farmed. In these areas deep, open ditches can be used to remove surface water and make cropping practicable. A tile drainage system can be installed, but precautions must be taken to insure that it will function. Tile placed in the sand may become plugged. Tile placed in the peat may go "offgrade" as the peat decomposes and settles.

Crop residue should be returned to keep good soil tilth. These fine-textured, light soils are susceptible to soil blowing. Use of cover crops, rough tillage, and field windbreaks helps to control soil blowing.

These soils generally contain an adequate amount of calcium but are commonly low in content of phosphorus and potassium. They are generally calcareous, although pH is variable.

CAPABILITY UNIT VIe-1

This unit consists of soils of the Langhei-Barnes-Sioux complex and of Langhei loam, 18 to 25 percent slopes.

The Sioux soil in this unit is of limited extent. These are well-drained to excessively drained soils having slopes of 12 to 25 percent.

Organic-matter content and nutrient supplying capacity are low to high. Some small areas are farmed, and they have been subject to severe erosion. The surface layer has been completely removed in these areas, and the organic-matter content and nutrient supplying capacity are lower. Available water capacity of the Langhei and Barnes soils is high; available water capacity of the Sioux soil is low.

These soils are best suited to grassland, but care must be taken not to overgraze them. Late in summer the soils generally become dry, and grasses growing on them become dormant. Permanent pasture can be improved by use of weed control measures, by practice of rotational and restricted grazing, and by application of fertilizer. Crops do not grow well on these soils.

Erosion is a severe hazard. Most slopes are so steep that most of the rainfall runs off rather than into the soil. Generally these soils become droughty by midsummer.

CAPABILITY UNIT VIs-1

Maddock loamy sand, 6 to 12 percent slopes, is the only soil in this unit. This is an excessively drained, eroded, rolling soil underlain by fine sand that provides an unrestricted root zone.

This soil is loose and is rapidly permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low.

This soil is so highly erodible that it is best suited to permanent grass. Practice of rotational and restricted grazing, control of weeds, and application of fertilizer will insure good grass production. Special care must be taken to prevent overgrazing during dry periods.

Droughtiness is a very severe problem. This soil generally is deficient of moisture by mid-July. Soil blowing is a constant hazard because the soil is so loose.

CAPABILITY UNIT VIw-1

This unit consists of Alluvial land; Lake beaches, loamy; Lake beaches, sandy; and Lamoure silt loam, wet. These are frequently flooded soils and land types that occur next to streams and lakes. Alluvial land is variable in texture, but it generally is loamy and contains layers of sand in the profile; it is commonly dissected by stream meanders and includes some small, sandy areas.

These soils and land types are best suited to permanent vegetation. When they are used for pasture, it is important that weeds and brush be controlled. If they are grazed when they are too wet, they become hummocky and of less value as pastureland. The lower lying areas, where water is ponded most of the year, are best suited to wildlife. These areas may further be improved as wildlife habitat by planting water-tolerant trees, shrubs, or grasses.

These soils and land types are flooded too frequently to be safely cultivated or are so cut up by old stream meanders that it is not practical to cultivate them. Suitable outlets for drainage are lacking because of the relationship of these soils and land types to the nearby lakes and streams. If a major improvement is made in the channels of streams passing through areas in this unit, some of them could be used as cropland. Streambank stabilization may be needed in places where bank cutting is active.

CAPABILITY UNIT VIIe-1

This unit consists of soils of the Langhei series. These are somewhat excessively drained, calcareous soils having slopes of 6 to 40 percent. They are loam in texture, are more than 60 inches deep, and have an unrestricted root zone.

Organic-matter content and nutrient supplying capacity are low. Available water capacity is high.

These soils are so steep or stony that they should be kept under a permanent cover of vegetation. They could provide fair pasture early in the season, but care should be taken to prevent overgrazing and creation of an erosion hazard. Pastureland can be improved by practice of restricted grazing, by control of weeds and brush, and by application of fertilizer. Water erosion is the most serious hazard on these soils. Because the slopes in most areas are steep, most of the rain runs off these soils and they never reach their available water capacity.

CAPABILITY UNIT VIIs-1

This unit consists of soils of the Maddock, Salida, and Sioux series. These are excessively drained, sandy and gravelly soils having slopes of 6 to 35 percent. The surface layer is loamy sand or gravelly sandy loam underlain by sand and gravel, which provides an unrestricted root zone.

These soils are loose and are rapidly permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low to very low.

These soils are so highly erodible and unproductive that they are best suited to permanent grass. Rotational and restricted grazing should be practiced, and weeds should be controlled. Care must be taken to prevent overgrazing.

Droughtiness is a very severe limitation. These soils generally are deficient of moisture by mid-July. Soil blowing is a hazard because of the looseness of the soil. Erosion is a very severe hazard, and occasionally gullying is severe.

CAPABILITY UNIT VIIIw-1

This unit consists of Marsh and of Muck, calcareous, seeped. These are very poorly drained soils that generally are covered by marsh vegetation. Most areas of these soils cannot be drained because they lack outlets or because ground water keeps the area seepy. These areas are best suited to wildlife habitat. They can provide very good cover for waterfowl, muskrat, and upland game.

Predicted yields

Table 2 gives predicted average acre yields for the principal crops grown in Pope County under two levels of management. These predictions are based on records and observations of the Soil Conservation Service, the Extension Service, the University of Minnesota, and the U.S. Census of Agriculture. They are also based on interviews with farmers. Under a medium level of management—

1. A planned cropping system generally is used, but seedings of grass-legume and green-manure crops occasionally fail where adequate attention is not given to cultural and management techniques.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*

[In columns A are average yields obtained under the management commonly used; in columns B are average yields obtained under improved management. Absence of a yield figure indicates crop is not suited to the soil or ordinarily is not grown on it]

Soil	Corn		Oats		Soybeans		Wheat		Barley		Corn for silage		Alfalfa hay		Alfalfa-bromegrass	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Alluvial land	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Arveson sandy loam	35	50	40	55	20	25	20	30	25	40	7	10	2	3	100	150
Barnes loam, 0 to 2 percent slopes	50	70	50	70	20	30	30	45	35	55	10	13	2. 5	3. 5	125	175
Barnes-Langhei loams, 2 to 6 percent slopes, eroded	45	70	50	70	20	30	30	45	35	55	8	12	2. 5	3. 5	125	175
Barnes-Langhei loams, 6 to 12 percent slopes, eroded	35	65	45	65	15	25	20	40	30	50	6	10	2	3	100	150
Barnes-Langhei-Renshaw loams, 2 to 6 percent slopes, eroded	40	55	50	65	20	25	20	30	25	40	8	12	1. 5	2. 5	75	125
Barnes-Langhei-Renshaw loams, 6 to 12 percent slopes	35	45	35	50	15	20	15	25	20	35	6	10	1. 5	2. 5	75	125
Bearden silt loam, 0 to 2 percent slopes	50	75	50	80	20	30	20	30	35	50	10	15	2. 5	3. 5	125	175
Blue Earth silt loam	65	85	40	65	25	30	----	----	----	----	6	14	1	3. 5	50	175
Canisteo loam	40	80	50	70	20	30	25	35	35	50	9	15	2. 5	4	125	200
Clarion loam, 2 to 6 percent slopes	50	85	50	80	25	35	25	35	35	50	14	19	2. 5	4	125	200
Clarion loam, 6 to 12 percent slopes, eroded	45	70	35	70	23	38	20	30	30	45	11	16	2	3	100	150
Clontarf sandy loam, 0 to 2 percent slopes	45	60	40	60	20	25	20	30	25	40	8	12	1. 5	2. 5	75	125
Colvin silty clay loam	45	80	45	70	20	30	25	35	30	45	9	15	2. 5	4	125	200
Colvin silty clay loam, depressional	40	65	40	65	20	25	20	35	35	50	6	12	1	3. 5	50	175
Darnen silt loam, 0 to 4 percent slopes	55	75	55	75	25	35	25	40	40	55	10	15	2. 5	4. 5	125	225
Dickinson sandy loam, 0 to 2 percent slopes	40	55	40	50	15	20	20	30	35	40	8	11	1. 5	2. 5	75	125
Dickinson sandy loam, 2 to 6 percent slopes	40	55	40	50	15	20	20	30	35	40	8	11	1. 5	2. 5	75	125
Doland silt loam, 0 to 2 percent slopes	50	75	50	75	20	30	30	45	35	55	10	14	2. 5	3. 5	125	175
Doland silt loam, 2 to 6 percent slopes	50	70	45	70	20	30	25	35	35	50	8	13	2. 5	3. 5	125	175
Estelline silt loam, 0 to 3 percent slopes	40	65	45	70	20	25	25	35	30	50	8	12	2	3	100	150
Estelline silt loam, moderately well drained variant	50	60	55	70	25	30	25	40	40	55	10	15	2. 5	3. 5	125	175
Estherville loam, 0 to 2 percent slopes	40	50	30	50	16	24	15	20	20	30	7	10	1. 5	2. 5	75	125
Estherville loam, 2 to 6 percent slopes	40	50	30	50	16	20	15	20	20	30	6	8	1. 5	2. 5	75	125
Estherville loam, 6 to 12 percent slopes, eroded	30	40	25	40	12	18	10	15	20	25	5	8	1. 5	2	75	100
Estherville loam, thick solum, 0 to 2 percent slopes	40	55	45	65	20	25	25	35	30	50	8	12	2	3	100	150
Estherville loam, thick solum, 2 to 6 percent slopes	35	50	45	65	20	25	25	35	30	50	8	12	2	3	100	150
Flandreau silt loam, 0 to 2 percent slopes	40	65	45	65	20	25	25	35	30	50	8	12	2	3	100	150
Flandreau silt loam, 2 to 6 percent slopes	40	65	45	65	20	25	25	35	30	50	8	12	2	3	100	150
Fordville loam, 0 to 2 percent slopes	40	65	45	70	20	25	25	35	30	50	8	12	2	3	100	150
Fordville loam, 2 to 6 percent slopes	35	65	45	70	20	25	25	35	30	50	8	12	2	3	100	150
Forman clay loam, 2 to 6 percent slopes, eroded	50	70	50	70	18	25	25	35	30	45	8	11	2. 5	3. 5	125	175
Forman clay loam, 6 to 12 percent slopes, eroded	40	65	45	65	15	20	20	30	30	40	6	10	2	3	100	150
Glencoe silty clay loam	55	85	45	75	20	30	20	35	35	50	6	15	1	3. 5	50	175
Hamar sandy loam	35	50	40	55	20	25	20	30	25	40	8	12	1. 5	2. 5	75	125
Hamerly loam, 0 to 3 percent slopes	45	65	50	75	20	25	20	35	35	45	10	15	2. 5	4	125	200
Hecla loamy sand, 0 to 3 percent slopes	25	40	30	45	10	15	15	20	20	30	5	8	1	2	50	100
Lake beaches, loamy	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lake beaches, sandy	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lamoure silt loam	50	80	50	70	20	25	25	35	35	50	10	15	2. 5	4	125	200
Lamoure silt loam, wet	60	80	40	80	25	30	20	30	30	45	10	15	2. 5	3. 5	125	175
Lamoure complex	35	65	40	65	25	35	20	30	20	35	10	15	2. 5	4. 0	125	200
Langhei loam, 18 to 25 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Langhei loam, 25 to 40 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Langhei stony loam, 6 to 40 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Langhei-Barnes loams, 2 to 6 percent slopes, eroded	35	60	45	65	12	20	18	30	25	35	7	10	2	3	100	150
Langhei-Barnes loams, 6 to 12 percent slopes, eroded	25	55	40	60	8	18	15	30	25	35	6	9	2	3	100	150
Langhei-Barnes loams, 12 to 18 percent slopes, eroded	25	45	30	50	5	15	10	25	15	30	3	10	----	----	75	100
Langhei-Barnes-Sioux complex, 12 to 18 percent slopes, eroded	20	30	15	25	5	15	5	15	8	20	4	7	1	2	50	100
Maddock loamy sand, 6 to 12 percent slopes	20	30	20	30	8	12	15	25	20	30	4	6	1	2	50	100

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn		Oats		Soybeans		Wheat		Barley		Corn for silage		Alfalfa hay		Alfalfa-bromegrass	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Maddock loamy sand, 12 to 25 percent slopes	15	25	15	25	5	10	10	15	15	20	----	----	1	2	50	100
Maddock sandy loam, 0 to 2 percent slopes	25	40	25	45	10	15	15	25	25	35	5	10	1	2	50	100
Maddock sandy loam, 2 to 6 percent slopes	20	35	25	40	10	15	15	25	25	35	5	10	1	2	50	100
Malachy sandy loam, 0 to 2 percent slopes	45	60	40	55	20	25	30	40	35	45	8	12	1.5	2.5	75	125
Marsh	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Marysland loam	45	60	50	65	25	30	25	35	30	45	6	12	2	3	100	150
Mayer loam	45	60	50	65	25	30	20	35	25	45	9	12	2	3	100	150
Mayer loam, depressional	35	50	45	55	20	25	20	35	35	50	6	12	1	3.5	50	175
Mayer loam, sandy subsoil variant	45	60	50	65	25	30	20	35	25	45	9	12	2	3	100	150
McIntosh silt loam, 0 to 2 percent slopes	45	70	50	75	20	25	25	35	30	50	10	15	2.5	4	125	200
Muck	55	75	35	50	20	30	----	----	----	----	5	16	----	----	----	----
Muck, calcareous	30	70	----	----	20	30	----	----	----	----	5	16	----	----	----	----
Muck, calcareous, seeped	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Muck, calcareous, over loam	30	65	----	----	20	30	----	----	----	----	5	16	----	----	----	----
Muck, calcareous, over sand	30	65	----	----	20	30	----	----	----	----	5	16	----	----	----	----
Muck over loam	30	70	----	----	20	30	----	----	----	----	5	16	----	----	----	----
Muck over sand	30	70	----	----	20	30	----	----	----	----	5	16	----	----	----	----
Nicollet loam, 0 to 3 percent slopes	55	80	55	80	25	35	25	35	40	55	15	20	2.5	4	125	200
Nutley silty clay loam, 0 to 2 percent slopes	50	60	45	65	20	25	25	35	30	45	9	12	2.5	3.5	125	175
Nutley silty clay loam, 2 to 6 percent slopes	50	60	45	65	20	25	25	35	30	45	9	12	2.5	3.5	125	175
Oldham silty clay loam	50	80	40	70	20	30	20	35	35	50	6	13	1	3.5	50	175
Osakis sandy loam, 0 to 2 percent slopes	35	50	35	50	15	25	20	30	25	40	7	10	1.5	2	75	100
Parnell silty clay loam	45	80	45	75	20	25	20	35	35	50	6	15	1	3.5	50	175
Parnell and Flom silty clay loams	50	80	50	70	20	30	30	40	35	55	9	15	2.5	4	125	200
Perella silty clay loam	40	60	50	75	20	30	30	40	35	50	10	15	2.5	4	125	200
Renshaw loam, 0 to 2 percent slopes	40	50	30	45	12	18	15	20	15	25	7	10	1.5	2	75	100
Renshaw loam, 2 to 6 percent slopes	35	50	25	40	10	15	15	20	15	25	6	8	1.5	2	75	100
Renshaw loam, 6 to 12 percent slopes, eroded	25	35	25	35	8	12	5	10	5	10	5	8	1.5	2	75	100
Salida sandy loam, 0 to 6 percent slopes	20	30	20	30	10	15	----	----	----	----	5	8	1	1.5	50	75
Salida sandy loam, 6 to 12 percent slopes, eroded	20	30	20	30	8	15	----	----	----	----	----	----	----	----	----	----
Salida gravelly sandy loam, 12 to 35 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Sioux sandy loam, 0 to 6 percent slopes	20	30	20	30	10	15	----	----	----	----	5	8	1	1.5	50	75
Sioux sandy loam, 6 to 12 percent slopes, eroded	20	30	20	30	8	15	----	----	----	----	3	7	1	1.5	50	75
Sioux gravelly sandy loam, 6 to 35 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Storden-Clarion loams, 12 to 25 percent slopes, eroded	25	45	30	50	5	15	----	----	----	----	7	10	1.5	2.0	75	100
Svea loam, 0 to 2 percent slopes	55	75	60	80	25	30	30	40	40	55	10	15	2.5	4	125	200
Svea loam, 2 to 4 percent slopes	55	75	55	70	25	30	25	35	40	55	10	15	2.5	3.5	125	175
Sverdrup loam, 0 to 2 percent slopes	35	50	35	50	12	18	15	25	25	35	7	10	1.5	2.5	75	125
Sverdrup sandy loam, 2 to 6 percent slopes, eroded	35	50	35	50	12	18	15	25	25	35	7	10	1.5	2.5	75	125
Sverdrup sandy loam, 6 to 12 percent slopes, eroded	25	45	35	45	10	15	15	20	15	25	6	8	1	2	50	100
Tara silt loam, 0 to 3 percent slopes	55	75	55	70	25	30	25	40	40	55	10	15	2.5	4	125	200
Tonka silt loam	45	80	45	70	20	30	20	30	40	50	8	16	1	4	50	200
Vallers silty clay loam	50	80	50	70	20	30	25	35	35	50	9	15	2.5	4	125	200
Wadena loam	60	80	55	75	25	30	20	35	25	45	8	12	2	2.5	100	150
Waukon loam, 0 to 2 percent slopes	50	70	50	75	20	25	30	45	35	55	8	12	2.5	3.5	125	175
Waukon loam, 2 to 6 percent slopes	45	65	35	60	20	25	30	45	35	55	8	12	2.5	3.5	125	175
Waukon loam, 6 to 12 percent slopes	40	55	35	50	15	20	24	40	30	50	6	10	2	3	100	150
Waukon loam, 12 to 18 percent slopes	30	60	30	40	10	12	10	15	15	20	5	8	1.5	2.5	75	125
Waukon clay loam, 2 to 6 percent slopes, eroded	35	55	35	55	17	20	20	25	20	35	6	10	2.5	3.5	125	175
Waukon clay loam, 6 to 12 percent slopes, eroded	30	45	35	45	13	18	20	25	20	35	5	9	2	3	100	150
Webster loam	50	85	55	75	26	38	25	35	35	50	9	15	2.5	4	125	200
Winger silty clay loam	45	80	40	70	20	25	25	35	30	50	10	15	2.5	4	125	200

[1] Animal-unit-days is a term used to express the carrying capacity of pasture. This value is obtained by multiplying the number of animal units carried per acre by the number of days the pasture can be grazed during a single season without injury to the sod.

2. Surface drainage and internal drainage are improved but not enough to provide optimum conditions for plant growth on soils that have restricted drainage.
3. A moderate amount of fertilizer is used, but a more adequate soil testing and fertilization program is needed.
4. All crop residue is returned to the soil either directly or through its use as bedding or for grazing.
5. Seedbed preparation is sometimes either inadequate or excessive and may be carried out when the soil is too wet or too dry.
6. Weed competition or insect damage frequently contributes to lowered crop yields.
7. Crop varieties, seed quality, and plant population may be inadequate for the soil.
8. Erosion control generally is practiced, but additional control measures may be needed.
9. Field operations usually are timely.

Under a high level of management—

1. Surface drainage and internal drainage provide optimum conditions for plant growth on soils that have restricted drainage.
2. Phosphorus, potassium, and nitrogen are applied according to soil tests and crop needs.
3. All crop residue is returned to the soil either directly or through use as bedding or for grazing.
4. Seedbeds are prepared as follows:
   (a) Fields are plowed in fall, but furrows are left rough over winter. Green-manure crops are plowed no earlier than October 1 of the seeding year; or
   (b) Seedbed preparation is limited to that which is necessary for crop production. Tillage is avoided when the soil is wet.
5. Weeds and insects are adequately controlled by cultural and chemical methods.
6. Crop varieties, seed quality, and plant population are as recommended for the particular soil and location.
7. Soil losses that result from soil blowing and water erosion are kept within allowable limits.
8. Field operations are carried out in a timely and efficient manner.
9. A planned conservation cropping system is used.

Table 3 gives predicted average acre yields for the principal plants grown for permanent pasture in Pope County. Predicted yields are for permanent pasture grown under two levels of management—medium and high. Under a medium level of management—

1. Fertilizer is applied infrequently and at rates that are too low for optimum forage yields.
2. Grazing is delayed in spring until grasses are 4 inches high, but pastures frequently are overgrazed later in the year.
3. Weeds and brush are partially controlled.
4. Drainage of wet sites is inadequate for maximum production of forage species and may cause inefficient use of forage by grazing livestock.

TABLE 3.—*Predicted average acre yields of permanent pasture under two levels of management*

[Absence of a yield figure indicates crop is not suited to the soil or ordinarily is not grown on it. Soils not listed in this table are not used extensively for permanent pasture in Pope County]

Soil	Bluegrass		Reed canarygrass	
	A	B	A	B
	Animal-unit days [1]	*Animal-unit days* [1]	*Animal-unit days* [1]	*Animal-unit days* [1]
Alluvial land	75	100	100	250
Colvin silty clay loam, depressional			100	250
Glencoe silty clay loam			100	250
Langhei-Barnes loams, 12 to 18 percent slopes, eroded	45	90		
Langhei-Barnes-Sioux complex, 12 to 18 percent slopes, eroded	45	90		
Langhei loam, 18 to 25 percent slopes	40	80		
Langhei loam, 25 to 40 percent slopes	30	50		
Maddock loamy sand, 12 to 25 percent slopes	20	40		
Mayer loam, depressional			100	250
Muck			100	250
Muck, calcareous			100	250
Muck over loam			100	250
Muck over sand			100	250
Oldham silty clay loam			100	250
Parnell silty clay loam			100	250
Perella silty clay loam			100	250
Salida sandy loam, 12 to 35 percent slopes	20	40		
Sioux gravelly sandy loam, 6 to 35 percent slopes	20	40		
Storden-Clarion loams, 12 to 25 percent slopes, eroded	45	95		
Waukon loam, 12 to 18 percent slopes	45	95		

[1] Animal-unit-days is a term used to express the carrying capacity of pasture. This value is obtained by multiplying the number of animal units carried per acre by the number of days the pasture can be grazed during a single grazing season without injury to the sod.

Under a high level of management—

1. Fertilizer is applied according to soil test recommendations and forage crop needs.
2. Pastures are not overgrazed or rotation grazing is practiced as needed for high forage yields.
3. Weeds and brush are adequately controlled.
4. Drainage is adequate for the forage species being produced and for efficient use of the forage by livestock.

Field and Farmstead Windbreaks [2]

This subsection lists trees and shrubs that are suggested for use primarily in field and farmstead windbreaks. The soils in the county have been placed in windbreak suitability groups, and performance ratings of the woody

[2] JOHN HULTGREN, woodland conservationist, Soil Conservation Service, helped to prepare this subsection.

plants on the soils of all but one of the groups are presented in table 4. A discussion of the windbreak suitability groups follows.

Wooded areas in Pope County generally are interspersed with fields and pastureland and are mostly on stream bottoms and on valley slopes. Wooded areas are largest and most common in the hilly terminal moraine area that crosses the county from Reno Township southeastward through Minnewaska, Barsness, Gilchrist, and Lake Johanna Townships. Basswood, American elm, green ash, soft maple, sugar maple, bur oak, red oak, ironwood, and cottonwood are most common. Both trees and shrubs are important in windbreak plantings in Pope County.

Field windbreaks help to control soil blowing, to bring about a more uniform distribution of snow, and to reduce the moisture loss and damage caused by hot, dry winds (fig 10). Control of erosion is especially important on the coarse-textured soils.

TABLE 4.—*Performance ratings for various species of shrubs and trees*

[Performance ratings are: 1, preferred; 2, acceptable; and 3, not recommended. Group 10 is too wet to be rated]

Species	Windbreak suitability groups											
	1	2	3		4		5	6	7		8	9
			Un-drained	Drained	Un-drained	Drained			Un-drained	Drained		
	CONIFEROUS TREES											
Pine:												
Jack	2	1	3	2	3	3	3	1	3	1	1	2
Ponderosa	1	1	3	1	3	2	1	1	3	1	1	2
Red	1	1	3	2	3	3	3	1	3	2	1	2
White	2	2	3	2	3	3	3	2	3	3	1	3
Redcedar, eastern	1	1	3	2	3	2	1	1	3	1	1	1
Spruce:												
Black hills	2	1	3	2	3	2	2	1	3	1	1	2
Colorado	1	1	3	1	3	2	2	2	3	1	1	3
White	2	1	3	2	3	2	2	1	3	1	1	2
White-cedar, northern	1	1	2	1	3	1	3	3	2	1	2	3
	DECIDUOUS TREES											
Ash, green	1	2	2	1	2	1	1	2	1	1	1	3
Elm:												
American	1	2	2	1	3	1	1	3	2	1	2	3
Siberian	1	1	2	1	2	1	1	1	1	1	1	2
Hackberry	2	3	3	2	3	2	2	3	2	1	3	3
Honeylocust	2	2	3	2	3	2	1	2	3	2	1	2
Maple, soft	1	2	2	1	3	2	2	3	2	1	2	3
Poplar	1	2	1	1	2	1	1	3	1	1	2	3
Willow, white	1	2	1	1	2	1	1	3	1	1	2	3
	SMALL SHRUBS AND TREES											
Buffaloberry	1	1	2	1	3	2	1	1	2	1	2	1
Caragana	1	2	2	1	3	2	2	2	2	1	1	2
Crab apple, Siberian	1	1	3	2	3	2	1	1	2	1	1	2
Honeysuckle	1	1	2	1	2	1	1	2	2	1	2	2
Lilac	1	1	2	1	2	1	1	2	3	1	2	2
Maple, Ginnala	1	2	2	1	3	2	1	2	3	1	2	3
Plum, American	1	1	2	1	2	1	1	1	2	1	1	2
Russian-olive	1	2	2	1	2	1	1	2	1	1	1	2
Willow:												
Laurel	1	2	1	1	2	1	1	3	1	1	2	3
Purple-osier	1	2	1	1	2	1	1	2	1	1	2	2

Figure 10.—A one-row windbreak on Hecla loamy sand, 0 to 3 percent slopes. Trees are 4-year-old Siberian elms.

Farmstead windbreaks help to block off the cold northerly and westerly winds in winter; reduce damage from cyclonic winds; protect livestock in feedlots, which saves feed cost; reduce heating costs; reduce snow drifting; and protect gardens and orchards. In addition, wildlife is benefited, the value of real estate is increased, and outdoor living is made more enjoyable.

Windbreak suitability groups of soils

To help select the most suitable trees and shrubs for field and farmstead windbreaks on each soil, the soils of the county have been placed in windbreak suitability groups. A windbreak suitability group is made up of soils that have similar characteristics affecting the growth of trees and shrubs. The group in which each soil has been placed is given in the "Guide to Mapping Units" at the back of this survey.

The trees and shrubs suitable for field and farmstead windbreaks in Pope County are listed in table 4. Groups 3, 4, and 7 include poorly drained and very poorly drained soils and are therefore rated for both the undrained and drained condition. Performance of each species on soils in the first nine groups has been rated as *preferred*, *acceptable*, or *not recommended*. The species rated as acceptable can be expected to grow but they are not so desirable as the preferred species. Species rated as not recommended are not suitable for planting on the soils in the group.

These performance ratings are based on soil characteristics that affect growth and survival of the trees and shrubs listed in the table. Texture, drainage, depth, reaction, stoniness, and steepness and direction of slope are important soil characteristics. The descriptions of the windbreak suitability groups that follow tell how these soil characteristics affect the performance of the trees and shrubs. Suggestions about the preparation of sites for planting are also given.

Further information on planning, protection, and care of windbreaks is available at the local offices of the Soil Conservation and the Agricultural Extension Service.

The names of the soil series represented are mentioned in the description of each suitability group, but the listing of the series name does not necessarily indicate that all the soils of a series are in the same suitability group. To find the windbreak suitability group of any given soil, refer to the "Guide to Mapping Units."

WINDBREAK SUITABILITY GROUP 1

This group consists of soils of the Barnes, Clarion, Darnen, Doland, Forman, Nicollet, Nutley, Svea, Tara, and Waukon series. These are well drained and moderately well drained soils that range in texture from loam to silty clay loam and are more than 60 inches deep. They formed mainly in glacial till but include some deep, silty soils.

These soils have an unrestricted root zone. Soil texture, permeability, and drainage allow moisture to penetrate deeply and promote a uniform distribution of roots. Available water capacity is high. The surface layer is neutral, and the parent material is mildly alkaline.

Most of the soils in this group are nearly level to gently sloping, and soil limitations are slight. Some of them are more strongly rolling, and erosion is a hazard and moisture conditions are less favorable.

WINDBREAK SUITABILITY GROUP 2

This group consists of soils of the Estelline, Estherville, thick solum, Flandreau, Fordville, and Wadena series. These are well-drained and excessively drained soils that range in texture from loam to silt loam and are underlain by sand or gravel at a depth of 24 to 40 inches. These level to gently sloping soils occur on uplands and on stream terraces.

The upper layers of these soils provide a root zone that favors the growth of young plants and shrubs. Available water capacity is moderate. Reaction is neutral in the loamy upper layers and mildly alkaline in the coarse-textured substratum.

The soils in this group have lower available water capacity than do those in windbreak group 1. Use of moisture conserving measures will provide a better root environment for plants. In sloping areas trees can be planted on the contour. Control of weeds is important, since they consume much water in growth.

WINDBREAK SUITABILITY GROUP 3

This group consists of soils of the Flom, Glencoe, Parnell, Perella, Tonka, and Webster series. These are poorly drained and very poorly drained soils that range in texture from loam to silty clay loam and are more than 60 inches deep. They are in level and depressional areas throughout the county. Where these soils occur in potholes that do not have adequate surface drainage, they should be considered with the soils in windbreak group 10.

The root zone in these soils is determined by the depth to the water table, which is within 2 feet of the surface in spring where undrained. Surface water should be removed quickly in spring and the water table lowered by drainage in order to provide a thicker root zone. The available water capacity is high. The surface layer is neutral, and the parent material is mildly alkaline.

Where drained, these soils are well suited to trees and shrubs. Competition from weeds is severe.

WINDBREAK SUITABILITY GROUP 4

This group consists of soils of the Canisteo, Colvin, Lamoure, Oldham, Vallers, and Winger series. These are poorly drained and very poorly drained, high-lime soils that range in texture from loam to silty clay loam and are more than 60 inches deep. Where they occur in potholes, and do not have adequate drainage, they should be considered with the soils in windbreak group 10.

The root zone in these soils is determined by the depth to the water table. If undrained, the water table is within 2 feet of the surface in spring. Surface water should be removed quickly in spring and the water table lowered by drainage in order to provide a thicker root zone.

Available water capacity is high. Reaction is moderately alkaline. These are strongly calcareous soils, and the high lime content affects the growth of trees and shrubs by "tying up" plant nutrients. Young plants are often yellowish in color and grow slowly until their roots have penetrated the strongly calcareous layer, after which they have good color and grow well.

WINDBREAK SUITABILITY GROUP 5

This group consists of soils of the Bearden, Hamerly, Langhei, McIntosh, and Storden series. These are level to steep, somewhat excessively drained to moderately well drained, high-lime soils. They range in texture from loam to silt loam and are more than 60 inches deep.

Available water capacity is high. Reaction is mildly alkaline to moderately alkaline. These soils are limited by droughtiness, low fertility, and poor tilth. On the Hamerly soil, the surface layer is often eroded and has low organic-matter content.

The root zone of the soils in this group is restricted by the high content of lime in the upper part of the profile, which affects the growth of trees and shrubs by "tying up" plant nutrients. The young plants often are yellowish in color and are stunted until their roots have penetrated the calcareous layers. Moisture conserving practices such as weed control help to increase plant survival.

WINDBREAK SUITABILITY GROUP 6

This group consists of soils of the Dickinson, Estherville, Hecla, Maddock, Osakis, Renshaw, and Sverdrup series. These are level to steep, droughty, moderately well drained to somewhat excessively drained soils. The surface layer ranges in texture from loam to loamy sand and is underlain by sand and gravel at a depth of 12 to 24 inches.

These soils have a very restricted root zone. Available water capacity is very low. Reaction is slightly acid to neutral. Trees planted on these soils generally grow slowly and are stunted, and they generally are shorter lived than similar species planted on deeper soils.

Moisture conserving practices are needed to increase the survival rate of young plants. Where these soils are sloping, trees should be planted on the coutour. Control of weeds is needed to reduce competition for available moisture. Mulching the soil between trees reduces evaporation.

Young plants should be protected from damage by soil blowing. A row of corn planted parallel to the young plants protects them from soil blowing.

WINDBREAK SUITABILITY GROUP 7

This group consists of soils of the Arveson, Hamar, Marysland, and Mayer series; the Mayer series, sandy subsoil variant; and of Lake beaches, sandy. They are dominantly loam and sandy loam in texture and are underlain by sand and gravel at a depth of 12 to 26 inches. These are poorly drained to very poorly drained, nearly level to depressional soils. Where they occur in potholes that do not have adequate surface drainage, they should be considered with the soils in group 10.

The root zone of these soils is restricted by the coarse-textured underlying material and by the depth to the water table. Where undrained, the water table is within 2 feet of the surface. Drainage is needed to remove surface water quickly in spring and to lower the water table in order to provide a thicker root zone.

Available water capacity is moderate. Reaction is neutral to mildly alkaline. The Hamar soils are noncalcareous in the solum. The other soils contain an excessive amount of lime, which "ties up" plant nutrients. Young plants often are yellowish in color and grow slowly until a good root system has been established. Competition from weeds is severe.

WINDBREAK SUITABILITY GROUP 8

This group consists of soils of the Clontarf and Malachy series and of the Estelline series, moderately well drained variant. These are nearly level to gently sloping, moderately well drained soils. They are sandy loam and silt loam in texture and are underlain by sand at a depth of 18 to 30 inches.

These soils have an unrestricted root zone. Soil texture, permeability, and drainage allow deep penetration and uniform distribution of plant roots. Available water capacity is low. The water table is at a depth of 3 to 7 feet. Reaction ranges from neutral to moderately alkaline. The Malachy soil has a limy surface layer that can slow the growth of young plants for a short time, but they soon develop a good root system.

Droughtiness and soil blowing are hazards for new plants. A row of corn planted parallel to the trees or shrubs reduces soil blowing. The mulching of the surface layer between the plants and the control of weeds helps to conserve moisture.

WINDBREAK SUITABILITY GROUP 9

This group consists of soils of the Salida and Sioux series. These are level to steep, droughty, very thin soils that are underlain by gravel at a depth of less than 1 foot. Available water capacity is very low. Reaction is neutral to moderately alkaline.

Trees growing on these soils grow slowly and are stunted. Seedling mortality is very high because it is difficult for plants to become established.

WINDBREAK SUITABILITY GROUP 10

This group consists of soils of the Blue Earth and Lamoure series, and of Alluvial land, Lake beaches, loamy, Marsh, and Muck. These are very wet soils and land types that range from muck to sand to silt loam.

The soils and land types in this group generally are not suited to trees and shrubs. If trees are grown, however, white-cedar, willow, and possibly poplar would be best suited. Onsite investigations should be made to determine plant suitability before making decisions on land use.

Wildlife and Recreation [3]

This subsection rates the soils in Pope County as to their suitability for the development of wildlife and recreation areas. Then it gives interpretations as to the suitability of the soils for the development of various recreational facilities.

Wildlife and recreation areas

Pope County is located on the southwestern edge of the lake and resort region of Minnesota. It is served by State Highways 28, 29, and 55. State Highway 55 is a major route connecting Pope County with the Minneapolis-St. Paul area. The county is therefore in a good position to improve its economic growth by developing recreation areas.

Pope county has several lakes that are used intensively for recreation. Among these, are Lakes Minnewaska, Amelia, and Pelican. Recreation uses include boating, swimming, water skiing, and year-round fishing. Intensive development of cottages and year-round homes is taking place. Other lakes, such as Lake Reno, provide facilities for fishing and hunting. Still other lakes such as Lakes Linka, Gilchrist, and Scandinavian have potential for the development of various recreational facilities. Gilchrist Township has a suitable site for the construction of a 2,500 acre lake.

The wildlife and recreation resources of Pope County can be grouped into nine areas that correspond with the soil associations in the county. Suitability ratings of the potential of the areas for the production of wildlife habitat are given in table 5. Additional information on these resource areas is given in the following paragraphs.

Area 1 (*Barnes-Langhei-Doland association*).—This is a level to sloping area that has several shallow lakes and is spotted with sloughs and potholes. It has high potential for production of wildlife habitat elements and therefore has good potential for guest hunting farms. The numerous lakes and sloughs provide habitat elements for waterfowl: duck hunting in these areas is very good.

TABLE 5.—*Potential of wildlife and recreation areas for production of habitat elements for specified kinds of wildlife* [1]

Area	Pheasants	Squirrels and rabbits	Ducks, minks, and muskrats	Deer
1	High	High	High	Medium.
2	Medium	High	Low [2]	High.
3	Low	High	Low [2]	High.
4	Low	High	Low [2]	High.
5	Low	Medium	Low	Low.
6	Medium	High	High	Medium.
7	Medium	Low to medium	Low [2]	Medium.
8	Medium	Medium	Medium	Medium.
9	Medium	Medium	High	Medium.

[1] Habitat management is employed as required.
[2] Potential for wetland development is high on the very poorly drained soils.

[3] JOHN W. BEDISH, biologist, Soil Conservation Service, helped to prepare this subsection.

The diverse cropping of this area and the numerous sloughs and potholes provide good cover and nesting areas. Deer hunting is fair to good. Lakes Reno and Pike provide fishing. Although there are several resorts and boat landings on Lake Reno, its poor shoreline discourages development. The soils in this area are well suited to the building of dugout pits or farm ponds that can provide additional hunting and fishing.

Area 2 (*Barnes-Langhei-Svea association*).—This is an undulating to rolling area that is marked by numerous potholes, sloughs, and shallow lakes. It has potential for development of vacation farms. Interesting hiking and riding trails can be developed through this variable landscape. Camping areas could be developed on some of the lakes that are near State highways.

The diverse cropping of this area and the idle and marshy areas provide good cover for wildlife. Leased hunting and hunter services could provide supplemental income to farmers during the hunting season. The lakes and sloughs provide nesting and resting areas for waterfowl; duck hunting in these areas is good. Pheasant hunting is very good. Deerhunting is good, particularly in the wooded areas near the lakes and along the creek bottoms. The soils in this area are well suited to the building of farm ponds (fig. 11) or dugout pits that can provide additional hunting and fishing facilities.

Area 3 (*Langhei-Barnes association*).—This is a rolling to hilly area that has many potholes and sloughs and some shallow lakes. The topography is rough and contrasting. This area is well suited to development of hiking and riding trails. There are many slopes that are long enough to be developed into short ski or toboggan runs for local enthusiasts.

The numerous sloughs in this area provide good mating and nesting areas for ducks. Because of the hilly topography, however, duck and pheasant hunting generally is poor, although some sloughs and small fields do provide good hunting. Deer hunting is good, particularly along the stream bottoms and in the wooded areas and draws. The soils in this area are suited to the building of farm ponds that could provide additional hunting and fishing.

Area 4 (*Langhei-Barnes-Waukon-Sioux association*).—This is a hilly to steep area that has many potholes and sloughs, several fishing lakes, and several shallow lakes. About 10 percent of it is wooded. There is potential for additional resort, cottage, and homesite development on several lakes. This rough topography is well suited to development of hiking and riding trails. Camping areas could be developed near Scandinavian or Gilchrist Lakes.

This area contains several good fishing lakes. Lakes Minnewaska, Pelican, Scandinavian, and Gilchrist all have resorts, boat landings, and cottages along the shore. Lakes

***Figure 11.*—Farm pond on Barnes loam, 6 to 12 percent slopes, eroded.**

Simon and Goose are large, shallow lakes that are frequented by waterfowl. The diversity of land use provides excellent cover for wildlife. The lakes and sloughs provide mating and nesting areas for waterfowl. Because the topography is so rough, however, and because of its effect on habitat elements, duck and pheasant hunting is poor in most places. Deer are numerous throughout the area. Archers have very good luck hunting on the stream bottoms, in the woods, and in the sloughs. Muskrats are common in the wet, marshy areas, and some mink and other fur-bearing animals are also present.

Area 5 (*Sioux-Maddock association*).—This is a hilly to steep (fig. 12), gravelly and sandy area that has some deep, enclosed potholes, some fishing lakes, and several shallow lakes. Most of this area is grassland.

Glacial Lake State Park, on the western shore of Signalness Lake, offers opportunities for camping, swimming, and fishing. Lake Linka is a good fishing lake and has an excellent beach. Further shoreline development of these lakes is limited by the steep topography. In some places there are long, uniform slopes that could be developed into ski and tobaggan runs for local enthusiasts.

Duck and pheasant hunting generally is poor because of the rugged topography and lack of proper habitat elements. Deer hunting is fair, particularly in the vicinity of the East Branch of the Chippewa River.

Area 6 (*Clarion-Canisteo-Nicollet association*).—This is a level to sloping area that has many sloughs and potholes. The numerous lakes and sloughs provide good habitat for waterfowl; duck hunting in these areas is good. The varied cropping of the land and the numerous marshes provide good cover and nesting areas. Deer hunting is fair to good, particularly in Grove Lake Township. The soils in this area are well suited to the building of dugout pits or farm ponds that can provide additional hunting and fishing facilities.

Area 7 (*Estherville-Muck association*).—This is a dominantly level area that is underlain by sand and gravel and contains several large marshes. Most of it is subject to drought, and farming is less intensive than in other parts of the county. Duck hunting is fair to good but is limited to the large sloughs and shallow lakes. Pheasant hunting is fair when the pheasant population is high. Deer hunting is good in the wooded areas along the lakes and streams. Lakes Villard, Amelia, and Grove provide good fishing and have resorts, boat landings, and cottages along the shore. Lakes Johanna, McCloud, and Westport are large and shallow and provide good habitat for waterfowl.

***Figure 12.*—Area of Sioux and Maddock soils in Lake Johanna Township.**

Area 8 (*Renshaw-Estelline association*).—This is a level to gently sloping, droughty area that is underlain by sand and gravel and has many small areas of marshland. The numerous marshes provide good habitat for waterfowl. Duck hunting is fair, and pheasant hunting is fair to good. A large part of the area is dissected by the Chippewa River, which has shrubs and trees growing along its banks. The area along the river provides good cover for upland game and deer. Bow hunters have good results hunting deer along the river. Lake Emily is a shallow lake that provides a resting area for waterfowl as well as some fishing.

Area 9 (*Marysland-Muck-Arveson association*).—This is a level to nearly level sandy area that is poorly drained and very poorly drained and has many areas of marsh. It is dissected by the Chippewa River and by several shallow ditches. This area provides cover for wildlife along the river, in the ditches, and in the numerous marshes. Several marshes are in the valley west of Lake Minnewaska. The ditches and the Chippewa River are natural travel routes for deer. Bow hunters have good results when hunting in these areas. The soils in this area are well suited to the digging of stock watering pits, which can provide additional wildlife habitat when properly developed.

Recreational Uses of the Soils

Table 6 rates the soils in the county as slightly, moderately, or severely limited for specified recreational uses. Such uses include campsite and picnic areas, intensive play areas, paths and trails, and building sites.

The significant features include depth to water table, hazard of flooding, compaction characteristics, drainage, permeability, and slope. Not all of these features are limiting for all of the specified uses, but most of them are limiting for most uses, and some of them for all. In addition, any one feature may not restrict all types of recreation equally.

TABLE 6.—*Interpretations for recreational development*

[Marsh (Mk) is not included in this table, because it is too variable to rate]

Soil	Degree of limitation and soil features that affect suitability for—			
	Campsites and picnic areas	Intensive play areas	Path and trails	Building sites
Alluvial land	Severe: flooding hazard.	Severe: flooding hazard.	Severe: flooding hazard.	Severe: flooding hazard.
Arveson sandy loam	Severe: poorly drained.	Severe: poorly drained.	Severe: muddy when wet.	Moderate: high water table.
Barnes loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Barnes-Langhei loams, 2 to 6 percent slopes, eroded.	Slight	Moderate: slope	Slight	Slight.
Barnes-Langhei loams, 6 to 12 percent slopes, eroded.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Barnes-Langhei-Renshaw loams, 2 to 6 percent slopes, eroded.	Slight	Moderate: slope	Slight	Slight.
Barnes-Langhei-Renshaw loams, 6 to 12 percent slopes.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Bearden silt loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Blue Earth silt loam	Severe: high water table; easily compacted when wet.	Severe: high water table; easily compacted when wet.	Severe: high water table; easily compacted when wet.	Severe: high water table.
Canisteo loam	Severe: poorly drained; slow permeabiltiy; flooding hazard.	Severe: poorly drained; slow permeability.	Severe: poorly drained; low trafficability; soil compaction.	Severe: high water table.
Clarion loam, 2 to 6 percent slopes	Slight	Slight	Slight	Slight.
Clarion loam, 6 to 12 percent slopes, eroded.	Slight	Moderate: slope	Slight	Moderate: slope.
Clontarf sandy loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Colvin silty clay loam	Severe: easily compacted when wet.	Severe: easily compacted when wet.	Severe: muddy and sticky.	Severe: high water table.
Colvin silty clay loam, depressional	Severe: easily compacted when wet.	Severe: easily compacted when wet.	Severe: muddy and sticky.	Severe: high water table.
Darnen silt loam, 0 to 4 percent slopes	Slight	Slight	Slight	Slight.
Dickinson sandy loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Dickinson sandy loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Doland silt loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Doland silt loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Estelline silt loam, 0 to 3 percent slopes	Slight	Slight	Slight	Slight.
Estelline silt loam, moderately well drained variant.	Slight	Slight	Slight	Slight.
Estherville loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Estherville loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Estherville loam, 6 to 12 percent slopes, eroded.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Estherville loam, thick solum, 0 to 2 percent slopes.	Slight	Slight	Slight	Slight.

TABLE 6.—*Interpretations for recreational development*—Continued

Soil	Degree of limitation and soil features that affect suitability for—			
	Campsites and picnic areas	Intensive play areas	Path and trails	Building sites
Estherville loam, thick solum, 2 to 6 percent slopes.	Slight	Moderate: slope	Slight	Slight.
Flandreau silt loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Flandreau silt loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Fordville loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Fordville loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Forman clay loam, 2 to 6 percent slopes, eroded.	Moderate: sticky and easily compacted when wet.	Moderate: slope	Moderate: slippery, sticky, and easily compacted when wet.	Slight.
Forman clay loam, 6 to 12 percent slopes, eroded.	Moderate: sticky and easily compacted when wet; slope.	Severe: slope	Moderate: slippery, sticky, and easily compacted when wet.	Moderate: slope.
Glencoe silty clay loam	Severe: flooding hazard; slippery and sticky.	Severe: flooding hazard; slippery and sticky.	Severe: flooding hazard; slippery and sticky.	Severe: flooding hazard; slippery and sticky.
Hamar sandy loam	Moderate: high water table.	Severe: wet	Moderate: occasionally ponded.	Moderate: high water table.
Hamerly loam, 0 to 3 percent slopes	Slight	Slight	Slight	Slight.
Hecla loamy sand, 0 to 3 percent slopes	Moderate: loose; subject to blowing.	Moderate: loose; subject to blowing.	Moderate: loose; subject to blowing.	Slight.
Lake beaches, loamy	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.
Lake beaches, sandy	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.
Lamoure silt loam	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.
Lamoure silt loam, wet	Severe: wet; flooding hazard.	Severe: wet; flooding hazard.	Severe: wet; flooding hazard.	Severe: wet; flooding hazard.
Lamoure complex	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.	Severe: wet; high water table; flooding hazard.
Langhei loam, 18 to 25 percent slopes	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Langhei loam, 25 to 40 percent slopes	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Langhei stony loam, 6 to 40 percent slopes	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.	Severe: slope; stoniness.
Langhei-Barnes loams, 2 to 6 percent slopes, eroded.	Slight	Moderate: slope	Slight	Slight.
Langhei-Barnes loams, 6 to 12 percent slopes, eroded.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Langhei-Barnes loams, 12 to 18 percent slopes, eroded.	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Langhei-Barnes-Sioux complex, 12 to 18 percent slopes, eroded.	Severe: steep slope	Severe: steep slope	Moderate: slope	Severe: slope.
Maddock loamy sand, 6 to 12 percent slopes	Moderate: loose; subject to blowing; slope.	Moderate: loose; subject to blowing. Severe where too steep.	Moderate: loose; subject to blowing.	Moderate: slope.
Maddock loamy sand, 12 to 25 percent slopes.	Severe: loose; slope.	Severe: loose; slope.	Severe: loose; slope.	Severe: loose; slope.
Maddock sandy loam, 0 to 2 percent slopes	Moderate: loose; subject to blowing.	Moderate: loose; subject to blowing.	Moderate: loose; subject to blowing.	Slight.
Maddock sandy loam, 2 to 6 percent slopes	Moderate: loose; subject to blowing.	Severe: loose; subject to blowing; slope.	Moderate: loose; subject to blowing.	Slight.
Malachy sandy loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Marysland loam	Severe: poorly drained; wet.	Severe: poorly drained; wet; muddy when wet.	Severe: poorly drained; wet; slippery and sticky when wet.	Severe: high water table.
Mayer loam	Severe: poorly drained.	Severe: poorly drained.	Severe: muddy and slippery when wet.	Severe: high water table.

TABLE 6.—*Interpretations for recreational development*—Continued

Soil	Degree of limitation and soil features that affect suitability for—			
	Campsites and picnic areas	Intensive play areas	Path and trails	Building sites
Mayer loam, depressional	Severe: poorly drained.	Severe: poorly drained.	Severe: muddy and slippery when wet.	Severe: high water table.
Mayer loam, sandy subsoil variant	Severe: poorly drained.	Severe: poorly drained.	Severe: muddy and slippery when wet.	Severe: high water table.
McIntosh silt loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Muck	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Muck, calcareous	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Muck, calcareous, seeped	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Muck, calcareous, over loam	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Muck, calcareous, over sand	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Muck over loam	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Muck over sand	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.	Severe: flooding hazard; wetness.
Nicollet loam, 0 to 3 percent slopes	Slight	Slight	Slight	Slight.
Nutley silty clay loam, 0 to 2 percent slopes	Moderate: slippery and sticky when wet; very slow permeability.	Moderate: slippery and sticky when wet; very slow permeability.	Moderate: slippery and sticky when wet; very slow permeability.	Slight.
Nutley silty clay loam, 2 to 6 percent slopes	Moderate: slippery and sticky when wet; very slow permeability.	Moderate: slippery and sticky when wet; very slow permeability; slope.	Moderate: slippery and sticky when wet; very slow permeability.	Slight.
Oldham silty clay loam	Severe: flooding hazard; slippery and sticky when wet.	Severe: flooding hazard; slippery and sticky when wet.	Severe: flooding hazard; slippery and sticky when wet.	Severe: flooding hazard.
Osakis sandy loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Parnell silty clay loam	Severe: flooding hazard; slippery and sticky when wet.	Severe: flooding hazard; slippery and sticky when wet.	Severe: flooding hazard; slippery and sticky when wet.	Severe: flooding hazard.
Parnell and Flom silty clay loams	Severe: poorly drained; slippery and sticky when wet.	Severe: poorly drained; slippery and sticky when wet.	Severe: poorly drained; slippery and sticky when wet.	Severe: high water table.
Perella silty clay loam	Severe: poorly drained; slippery and sticky when wet.	Severe: poorly drained; slippery and sticky when wet.	Severe: poorly drained; slippery and sticky when wet.	Moderate: high water table.
Renshaw loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Renshaw loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Renshaw loam, 6 to 12 percent slopes, eroded.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Salida sandy loam, 0 to 6 percent slopes	Moderate: loose; vegetation difficult to maintain; gravelly in places.	Moderate: loose; vegetation difficult to maintain; gravelly in places.	Moderate: loose	Slight.
Salida sandy loam, 6 to 12 percent slopes, eroded.	Moderate: loose; vegetation difficult to maintain; gravelly in places.	Moderate: loose; vegetation difficult to maintain; gravelly in places. Severe where slope is steep.	Moderate: loose	Moderate: slope.
Salida gravelly sandy loam, 12 to 35 perent slopes.	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Sioux sandy loam, 0 to 6 percent slopes	Moderate: loose; vegetation difficult to maintain; gravelly in places.	Moderate: loose; vegetation difficult to maintain; gravelly in places.	Moderate: loose	Slight.

TABLE 6.—*Interpretations for recreational development*—Continued

Soil	Degree of limitation and soil features that affect suitability for—			
	Campsites and picnic areas	Intensive play areas	Path and trails	Building sites
Sioux sandy loam, 6 to 12 percent slopes, eroded.	Moderate: loose; vegetation difficult to maintain; gravelly in places.	Severe: slope	Moderate: loose	Moderate: slope.
Sioux gravelly sandy loam, 6 to 35 percent slopes.	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Storden-Clarion loams, 12 to 25 percent slopes, eroded.	Moderate: slope	Severe: slope	Moderate: slope	Severe: slope.
Svea loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Svea loam, 2 to 4 percent slopes	Slight	Moderate: slope	Slight	Slight.
Sverdrup sandy loam, 2 to 6 percent slopes, eroded.	Slight	Moderate: slope	Slight	Slight.
Sverdrup sandy loam, 6 to 12 percent slopes, eroded.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Sverdrup loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Tara silt loam, 0 to 3 percent slopes	Slight	Slight	Slight	Slight.
Tonka silt loam	Severe: flooding hazard.	Severe: flooding hazard.	Severe: flooding hazard.	Severe: flooding hazard.
Vallers silty clay loam	Severe: poorly drained; slippery, sticky, and easily compacted when wet.	Severe: poorly drained; slippery, sticky, and easily compacted when wet.	Severe: poorly drained; slippery, sticky, and easily compacted when wet.	Moderate: high water table.
Wadena loam	Slight	Slight	Slight	Slight.
Waukon loam, 0 to 2 percent slopes	Slight	Slight	Slight	Slight.
Waukon loam, 2 to 6 percent slopes	Slight	Moderate: slope	Slight	Slight.
Waukon loam, 6 to 12 percent slopes	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Waukon loam, 12 to 18 percent slopes	Severe: slope	Severe: slope	Moderate: slope	Severe: slope.
Waukon clay loam, 2 to 6 percent slopes, eroded.	Slight	Moderate: slope	Slight	Slight.
Waukon clay loam, 6 to 12 percent slopes, eroded.	Moderate: slope	Severe: slope	Slight	Moderate: slope.
Webster loam	Severe: poorly drained; sticky, slippery, and easily compacted when wet.	Severe: poorly drained; sticky, slippery, and easily compacted when wet.	Severe: poor drainage; sticky, slippery, and easily compacted when wet.	Severe: high water table.
Winger silty clay loam	Severe: poorly drained; sticky, slippery, and easily compacted when wet.	Severe: poorly drained; sticky, slippery, and easily compacted when wet.	Severe: poorly drained; sticky, slippery, and easily compacted when wet.	Severe: high water table.

Engineering Uses of the Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of highways, airports, and pipelines, the foundations of buildings, facilities for storing water, structures for controlling erosion, and systems for irrigation, drainage, and sewage disposal. Among the properties most important to engineers are permeability, shear strength, plasticity, compaction characteristics, drainage, shrink-swell characteristics, grain size, and pH. Also important are topography, depth to water table, and depth to sand and gravel.

The information in this section can be used to—

1. Make studies that will aid in selecting and developing sites for industrial, business, residential, and recreational areas.
2. Make preliminary estimates of the soil properties that affect the planning of agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving soil.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, cables, and pipelines and in planning detailed investigations at the selected locations.
4. Estimate the size of drainage areas and the speed and volume of runoff from them for use in designing culverts and bridges.
5. Identify the soils along proposed highway routes so that preliminary estimates can be made for the thicknesses of flexible pavements.
6. Make preliminary evaluations of topography, surface drainage, internal drainage, depth to the water table, and other features that affect the

design of embankments, subgrades, and pavements.
7. Correlate performance of engineering structures with soil mapping units and thus develop information for overall planning that will be useful in designing and maintaining the structure.
8. Determine the suitability of soils for use in cross-country movement of vehicles and construction equipment.
9. Supplement other published information such as maps, reports, and aerial photographs for the purpose of making engineering maps and reports that can be used readily by engineers.
10. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The maps, soil descriptions, and other data in this survey are valuable in planning detailed engineering surveys. By using this information, an engineer can select soil mapping units and concentrate on the ones that are most suitable for the planned construction and in this manner reduce the number of soil samples needed for laboratory testing. It should be emphasized, however, that the interpretations in this subsection are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads or at a site where excavations are to be deeper than the depths of the layers here reported. Also, engineers and others should not assign specific values to ratings.

The soil mapping units shown on the maps in this survey may include small areas of a different soil material. These included soils may be as much as 2 acres in size. They are too small to be mapped separately but may be important in engineering planning.

Much of the information in this subsection is given in tables 7 and 8. In table 7 properties of the soils that are important to engineering are estimated. Table 8 indicates the suitability of soils for various engineering uses.

Additional information useful to engineers can be found in the sections "Descriptions of the Soils" and "Formation and Classification of the Soils" as well as in other sections of this survey.

Some of the terms used by the scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, and sand—may have special meaning in soil science. These and other special terms used in the soil survey are defined in the Glossary at the back of this survey.

Engineering classification systems

Two systems for classifying soil material are generally used by engineers. One is the system approved by the American Association of State Highway Officials (AASHO) (*1*), and the other is the Unified system adopted by the United States Department of Defense (*8*). Both systems are used in this survey and are explained in the following paragraphs.

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system, soil materials are classified in seven principal groups. These range from group A–1, consisting of gravelly soils, to group A–7, consisting of clayey soils. Soil material near a classification boundary is given a symbol for both classes; for example, A–2 or A–4. The estimated AASHO classification of the soils in the county is given in table 7. Highly organic soils, such as peat and muck are not included in the AASHO classification because their use as construction material or foundation material should be avoided.

Some engineers prefer to use the Unified soil classification system. In this system, soils are identified according to their textural and plasticity qualities, and their grouping with respect to their performances as engineering construction materials. Soil materials are divided into 15 classes; eight classes are for coarse-grained material, six classes are for fine-grained material, and one class is for highly organic material. Soils that have characteristics of two classes are designated by symbols for both classes; for example, CH or MH. The classes range from GW, consisting of well-graded gravels or gravel-sand mixtures with little or no fines, to Pt, consisting of peat and other highly organic soils. The soils of the county have been classified only in the SW, SP, SP–SM, SM, ML, ML–CL, CL, OL, CH, OH, GM, GW, GP, and Pt classes. The estimated classification of the soils according to the Unified system is given in table 7.

Engineering properties

In table 7 the soil series of the county and the symbols for mapping units are listed, and certain characteristics that are significant to engineering are described. The estimated classification according to the AASHO and Unified classification systems is given for each important layer. These estimates are based on information given in other parts of this survey and on experience with similar soils in this and other counties. Because bedrock is at a great depth in this county and is not significant to engineering, it is not mentioned in table 7.

Permeability of the soil as it occurs inplace was estimated. The estimates are based on the structure and porosity of the soil as it occurs inplace and on permeability tests on undisturbed cores of similar material.

Available water capacity, given in inches per inch of soil depth, refers to approximate amount of capillary water in the soil when the soil is wet to field capacity. When the soil is at the wilting point of common plants, this same amount of water will wet the soil material to a depth of 1 inch without deeper percolation. Data are needed on representative soils from undisturbed soil samples or from field measurements if reliable estimates are to be made.

Reaction as shown in the table is the estimated range in pH values for each major horizon as determined in the field. It indicates the acidity or alkalinity of the soils. Soil reaction in a range of 6.6 to 7.3 is called neutral, a lower pH range indicates acidity, and a higher range indicates alkalinity.

The shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. It is estimated on the basis of the amount and type of clay in the soil layers. In general, soils classified as A–7 and CH have high shrink-swell potential. Clean sands and gravels and those having a small amount of nonplastic to slightly plastic fines have low shrink-swell potential, as does most other nonplastic to slightly plastic soil material.

424–010—72——6

TABLE 7.—*Estimated*

[Alluvial land (Af), Lake beaches, sandy (La), and Marsh (Mk) are so variable that their properties were not rated. An asterisk in the units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (dominant profile)	Classification
			USDA texture
	Feet	*Inches*	
Arveson: As	2–5	0–8	Sandy loam
		8–15	Sandy loam
		15–60	Sand
*Barnes: BaA, BbB2, BbC2, BdB2, BdC. For Langhei part of BbB2, BbC2, BdB2, and BdC, and for Renshaw part of BdB2 and BdC, see their respective series.	10+	0–8	Loam
		8–19	Loam
		19–60	Loam
Bearden: Be	4–8	0–14	Silt loam
		14–28	Silt loam
		28–60	Silty clay loam
Blue Earth: Bh	0–4	0–8	Muck
		8–36	Silt loam and loam
		36–60	Sandy loam and sand, and loam
Canisteo: Ca	0–4	0–21	Loam
		21–60	Loam
Clarion: CmB, CmC2	10+	0–12	Loam
		12–33	Loam
		33–60	Loam
Clontarf: Cn	3–6	0–23	Sandy loam
		23–30	Loamy sand
		30–60	Sand
Colvin: Co, Cp	2–5	0–8	Silty clay loam
		8–15	Silty clay loam
		15–60	Silty clay loam
Darnen: DaB	10+	0–33	Silt loam and loam
		33–60	Loam
Dickinson: DcA, DcB	10+	0–9	Sandy loam
		9–20	Sandy loam
		20–60	Loamy sand, sand, and fine sand
Doland: DlA, DlB	10+	0–8	Silt loam
		8–22	Silt loam
		22–60	Loam
Estelline: Es, Et	8–15	0–14	Silt loam
		14–32	Silt loam and loam
		32–60	Sand and gravel
Estherville: EvA, EvB, EvC2, EwA, EwB	8–15	0–18	Loam
		18–60	Sand and gravel
Flandreau: FlA, FlB	8+	0–10	Silt loam
		10–25	Silt loam
		25–60	Loamy fine sand to sand
*Flom. Mapped only in complex with soils of the Parnell series.	2–5	0–15	Silty clay loam
		15–22	Loam
		22–60	Loam
Fordville: FoA, FoB	8+	0–8	Loam
		8–27	Loam
		27–60	Sand and gravel
Forman: FrB2, FrC2	10+	0–7	Clay loam
		7–25	Clay loam
		25–60	Loam

engineering properties

first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping to other series that appear in the first column of this table]

Classification—Continued		Percent passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A-4	95–100	90–100	36–45	2.0–6.0	0.10–0.14	7.4–7.8	Low.
SM	A-2	95–100	90–100	20–30	2.0–6.0	0.10–0.14	7.9–8.4	Low.
SP-SM	A-3	95–100	90–100	5–10	>6.0	0.04	7.4–7.8	Low.
OL	A-6	95–100	85–100	50–80	0.6–2.0	0.14–0.18	6.6–7.3	Moderate.
CL	A-6	95–100	85–100	50–80	0.6–2.0	0.14–0.18	6.6–7.3	Moderate.
CL	A-6	95–100	85–100	50–80	0.6–2.0	0.14–0.18	7.4–8.4	Moderate.
OL	A-7	95–100	90–100	80–95	0.6–2.0	0.18–0.23	7.4–7.8	Moderate.
ML	A-4	95–100	90–100	80–95	0.6–2.0	0.18–0.23	7.9–8.4	Moderate.
CL	A-6	95–100	90–100	80–95	0.6–2.0	0.18–0.23	7.4–7.8	Moderate.
OL	A-4	95–100	90–100	70–90	------------	0.25	7.9–8.4	Low.
OL	A-4	95–100	90–100	70–90	0.6–2.0	0.18–0.23	7.9–8.4	Low.
ML	A-4	95–100	90–100	50–80	0.6–2.0	0.14–0.18	7.4–7.8	Moderate.
OL	A-7	90–100	85–100	50–80	0.6–2.0	0.14–0.18	7.4–7.8	Moderate.
CL	A-6	90–100	85–100	50–80	0.6–2.0	0.14–0.18	7.9–8.4	Moderate.
OL	A-6	95–100	85–100	50–80	0.6–2.0	0.14–0.18	6.6–7.3	Low.
CL	A-6	95–100	85–100	50–80	0.6–2.0	0.14–0.18	6.6–7.3	Moderate.
CL	A-6	95–100	85–100	50–80	0.6–2.0	0.14–0.18	7.4–7.8	Moderate.
SM	A-2	95–100	90–100	20–35	2.0–6.0	0.10–0.14	6.6–7.3	Low.
SM	A-2	95–100	90–100	10–20	>6.0	0.04–0.06	7.4–7.8	Low.
SP-SM	A-3	95–100	90–100	5–10	>6.0	0.04	7.4–7.8	Low.
OL	A-7	95–100	90–100	80–90	0.2–0.6	0.19–0.21	7.4–7.8	High.
ML	A-7	95–100	90–100	85–95	0.2–0.6	0.19–0.21	7.9–8.4	High.
CL	A-6	95–100	90–100	85–95	0.2–0.6	0.19–0.21	7.4–7.8	High.
OL	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
ML	A-4	95–100	95–100	60–80	0.6–2.0	0.14–0.18	7.4–7.8	Low.
SM	A-2	95–100	90–100	25–35	2.0–6.0	0.10–0.14	6.1–6.5	Low.
SM	A-2	95–100	90–100	25–35	2.0–6.0	0.10–0.14	6.1–6.5	Low.
SP-SM	A-3	95–100	90–100	5–10	>6.0	0.02–0.06	6.1–6.5	Low.
OL	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
ML	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
CL	A-6	95–100	90–100	50–80	0.6–2.0	0.14–0.18	7.4–7.8	Low.
OL	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
ML	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
SW	A-1	60–90	40–50	3–5	>6.0	0.04	7.4–7.8	Low.
CL	A-4	95–100	90–100	50–80	0.6–2.0	0.14–0.18	6.1–6.5	Low.
GP	A-1	40–50	25–40	3–5	>6.0	0.04	7.4–7.8	Low.
OL	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
ML	A-4	95–100	95–100	80–90	0.6–2.0	0.18–0.23	6.6–7.3	Low.
SP-SM	A-3 or A-2	90–100	90–100	5–10	>6.0	0.04	7.4–7.8	Low.
OL	A-7	95–100	95–100	60–75	0.6–2.0	0.14–0.18	6.6–7.3	High.
CL	A-6	95–100	95–100	60–75	0.2–0.6	0.14–0.18	6.6–7.3	Moderate.
CL	A-6	95–100	95–100	60–75	0.6–2.1	0.14–0.18	7.4–7.8	Moderate.
OL	A-4	90–95	85–95	50–75	0.6–2.0	0.14–0.18	6.6–7.3	Low.
CL	A-4	90–95	85–95	50–75	0.6–2.0	0.14–0.18	6.6–7.3	Low.
GP	A-1	40–50	25–40	3–5	>6.0	0.04	7.4–7.8	Low.
CL	A-6	90–95	85–95	60–80	0.2–0.6	0.16–0.18	6.6–7.3	High.
CL	A-7	90–95	85–95	60–80	0.2–0.6	0.16–0.18	6.6–7.3	High.
CL	A-4	90–95	85–95	50–80	0.6–2.0	0.14–0.18	7.4–7.8	Moderate.

TABLE 7.—*Estimated*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (dominant profile)	Classification: USDA texture
	Feet	*Inches*	
Glencoe: Gn	0–2	0–16	Silty clay loam
		16–30	Loam
		30–60	Clay loam
Hamar: Hc	2–4	0–15	Sandy loam
		15–24	Loamy sand
		24–60	Sand
Hamerly: Hd	5–10	0–8	Loam
		8–15	Loam
		15–60	Loam
Hecla: Hv	3–6	0–19	Loamy sand
		19–60	Sand
Lake beaches, loamy: Lb	0–2	0–60	Loam
Lamoure: Lc, Lh, Lk	2–5	0–28	Silt loam
		28–48	Loam
		48–60	Sand
*Langhei: LlE, LlF, LmF, LnB2, LnC2, LnD2, LoD2. For Barnes part of LnB2, LnC2, LnD2, and LoD2, and for Sioux part of LoD2, see their respective series.	10+	0–8	Loam
		8–60	Loam
Maddock: MbC, MbE, MdA, MdB	10+	0–8	Sandy loam
		8–15	Loamy sand
		15–60	Sand
Malachy: Mf	3–7	0–18	Sandy loam
		18–26	Sandy loam
		26–60	Sand
Marysland: Ml	2–5	0–10	Loam
		10–26	Loam
		26–60	Sand
Mayer: Mn, Mo, Mr	0–5	0–19	Loam
		19–32	Loam
		32–60	Sand and gravel
McIntosh: Ms	4–8	0–16	Silt loam
		16–28	Silty clay loam
		28–60	Loam
Muck: Mt	0–2	0–60	Muck
Muck, calcareous: Mu	0–2	0–60	Muck
Muck, calcareous, seeped: Mv	0–2	----------	Muck
Muck, calcareous, over loam: Mw	0–2	0–24	Muck
		24–60	Loam
Muck, calcareous, over sand: Mx	0–2	0–24	Muck
		24–60	Sand
Muck over loam: My	0–2	0–24	Muck
		24–60	Loam
Muck over sand: Mz	0–2	0–24	Muck
		24–60	Sand
Nicollet: Nc	8–15	0–15	Loam
		15–30	Clay loam
		30–60	Loam

engineering properties—Continued

Classification—Continued		Percent passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OL	A-7	90–95	85–95	70–90	0. 2–0. 6	0. 19–0. 21	6. 6–7. 3	Moderate.
CL	A-7	90–95	85–95	50–80	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
CL	A-6	90–95	85–95	50–80	0. 2–0. 6	0. 16–0. 18	6. 6–7. 3	High.
SM	A-4	95–100	90–100	36–50	2. 0–6. 0	0. 10–0. 14	6. 6–7. 3	Low.
SM	A-2	95–100	90–100	15–25	>6. 0	0. 06–0. 08	6. 6–7. 3	Low.
SP–SM	A-2	95–100	90–100	5–10	>6. 0	0. 04	7. 4–7. 8	Low.
OL	A-4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
CL	A-4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 9–8. 4	Low.
CL	A-4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
SM	A-2	95–100	90–100	20–30	>6. 0	0. 04–0. 06	6. 6–7. 3	Low.
SP–SM	A-2	95–100	90–100	5–10	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
CL	A-6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
OL	A-4	95–100	90–100	60–90	0. 6–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A-4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
SP–SM	A-2	80–100	80–100	5–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A-6	90–100	85–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
CL	A-6	90–100	85–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 9–8. 4	Moderate.
SM	A-2	95–100	90–100	20–35	2. 0–6. 0	0. 10–0. 14	6. 6–7. 3	Low.
SM	A-2	95–100	90–100	15–20	>6. 0	0. 04–0. 06	6. 6–7. 3	Low.
SP–SM	A-3 or A-2	95–100	90–100	5–10	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
SM	A-4	95–100	90–100	36–45	2. 0–6. 0	0. 10–0. 14	7. 4–7. 8	Low.
SM	A-2	95–100	90–100	20–35	2. 0–6. 0	0. 10–0. 14	7. 4–7. 8	Low.
SP–SM	A-3 or A-2	95–100	90–100	5–10	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A-6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
CL	A-6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 9–8. 4	Low.
SP–SM	A-3 or A-2	95–100	90–100	5–10	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A-6	95–100	90–100	60–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
CL	A-6 or A-4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
GP	A-2	40–50	25–40	3–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A-4	95–100	90–100	80–90	0. 6–2. 0	0. 18–0. 23	7. 4–7. 8	Moderate.
ML	A-4	95–100	90–100	80–90	0. 6–2. 0	0. 19–0. 21	7. 9–8. 4	Moderate.
CL	A-6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
Pt	----------	----------	----------	----------	----------	0. 25	6. 6–7. 3	Low.
Pt	----------	----------	----------	----------	----------	0. 25	7. 4–7. 8	Low.
Pt	----------	----------	----------	----------	----------	0. 25	7. 4–7. 8	Low.
Pt	----------	----------	----------	----------	----------	0. 25	7. 4–7. 8	Low.
CL	A-6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
Pt	----------	----------	----------	----------	----------	0. 25	7. 4–7. 8	Low.
SP–SM	A-2	90–100	80–95	5–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
Pt	----------	----------	----------	----------	----------	0. 25	6. 6–7. 3	Low.
CL	A-6	95–100	90–100	50–100	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
Pt	----------	----------	----------	----------	----------	0. 25	6. 6–7. 3	Low.
SP–SM	A-2	90–100	80–95	5–12	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A-4	95–100	90–100	65–80	0. 6–2. 0	0. 14–0. 18	6. 6–7. 7	Low.
CL	A-7	95–100	90–100	65–80	0. 6–2. 0	0. 16–0. 18	6. 6–7. 3	High.
CL	A-6	95–100	90–100	60–75	0. 6–2. 0	0. 14–0. 18	7. 4–8. 4	Moderate.

TABLE 7.—*Estimated*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (dominant profile)	Classification
			USDA texture
	Feet	*Inches*	
Nutley: NuA, NuB	5–10	0–12	Silty clay loam
		12–29	Clay
		29–60	Silt loam
Oldham: Om	0–3	0–34	Silty clay loam
		34–60	Silty clay loam
Osakis: Os	4–8	0–16	Sandy loam
		16–60	Sand and gravel
*Parnell: Pa, Pf	0–3	0–14	Silty clay loam
For Flom part of Pf, see Flom series.		14–18	Silt loam
		18–38	Silty clay loam
		38–60	Clay loam
Perella: Pr	2–4	0–22	Silty clay loam
		22–60	Silty clay loam
Renshaw: ReA, ReB, ReC2	8+	0–11	Loam
		11–19	Loam
		19–60	Sand and gravel
Salida: SdB, SdC2, SeF	8+	0–8	Sandy loam
		8–60	Sand and gravel
Sioux: SlB, SlC2, SoF	8+	0–8	Sandy loam
		8–60	Sand and gravel
*Storden: SrE2	10+	0–7	Loam
For Clarion part of SrE2, see Clarion series.		7–60	Loam
Svea: SuA, SuB	6–12	0–13	Loam
		13–22	Loam
		22–60	Loam
Sverdrup: SyB2, SyC2, SzA	8+	0–16	Loam
		16–20	Sandy loam
		20–60	Sand
Tara: Ta	6–12	0–15	Silt loam
		15–23	Silt loam
		23–60	Loam
Tonka: To	0–4	0–10	Silt loam
		10–16	Very fine sandy loam
		16–38	Clay
		38–60	Clay loam
Vallers: Va	2–4	0–12	Silty clay loam
		12–21	Clay loam
		21–60	Loam
Wadena: Wa	4–7	0–25	Loam
		25–36	Loam and sandy loam
		36–60	Sand and gravel
Waukon: WbA, WbB, WbC, WbD, WdB2, WdC2	10+	0–7	Loam
		7–26	Clay loam
		26–60	Loam
Webster: We	2–4	0–18	Loam and clay loam
		18–60	Loam
Winger: Wn	2–4	0–13	Silty clay loam
		13–26	Silty clay loam
		26–33	Silt loam
		33–60	Loam

engineering properties—Continued

Classification—Continued		Percent passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OH	A–7	95–100	90–100	70–80	0. 2–0. 6	0. 19–0. 21	6. 6–7. 3	High.
CH	A–7	95–100	90–100	80–90	>0. 06	0. 15–0. 18	6. 6–7. 3	High.
ML	A–4	95–100	90–100	60–85	0. 6–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
OL	A–7	95–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	7. 4–7. 8	High.
CL	A–6	95–100	90–100	70–85	0. 2–0. 6	0. 19–0. 21	7. 4–7. 8	High.
SM	A–4	80–95	70–90	36–50	2. 0–6. 0	0. 10–0. 14	6. 6–7. 3	Low.
GP	A–2	40–50	25–40	3–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A–7	95–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	6. 6–7. 3	High.
ML	A–4	95–100	90–100	80–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
CH	A–7	95–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	6. 6–7. 3	High.
CL	A–6	95–100	90–100	80–90	0. 2–0. 6	0. 16–0. 18	6. 6–7. 3	High.
OL	A–7	95–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	6. 6–7. 3	High.
CL	A–6	95–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	7. 4–7. 8	High.
CL	A–4	95–100	85–95	50–80	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
CL	A–4	95–100	85–95	50–80	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
GP	A–1	40–50	25–40	3–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
SM	A–4	80–95	80–95	35–50	2. 0–6. 0	0. 10–0. 14	6. 6–7. 3	Low.
GP	A–1	40–50	25–40	3–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
SM	A–4	80–95	80–95	35–50	2. 0–6. 0	0. 10–0. 14	7. 4–7. 8	Low.
GP	A–1	40–50	25–40	3–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
CL	A–6	90–100	90–95	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
CL	A–6	90–100	90–95	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
OL	A–6 or A–4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
CL	A–6 or A–4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
CL	A–6 or A–4	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
ML–CL	A–4	90–100	85–100	50–90	0. 6–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
SM	A–4	90–100	85–100	36–50	2. 0–6. 0	0. 10–0. 14	7. 4–7. 8	Low.
SP	A–2	85–100	80–90	3–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A–4	95–100	90–100	60–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	60–90	0. 6–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
CL	A–6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
OL	A–4	95–100	90–100	60–90	0. 6–2. 0	0. 18–0. 23	6. 1–6. 5	Low.
ML	A–4	95–100	90–100	60–85	2. 0–6. 0	0. 12–0. 16	6. 1–6. 5	Low.
CH	A–7	95–100	90–100	70–90	<0. 06	0. 15–0. 18	6. 1–6. 5	High.
CL	A–6	95–100	90–100	50–80	0. 2–0. 6	0. 16–0. 18	7. 4–7. 8	High.
OL	A–7	95–100	90–100	80–90	0. 2–0. 6	0. 18–0. 21	7. 4–7. 8	High.
CL	A–6	95–100	90–100	60–80	0. 2–0. 6	0. 16–0. 18	7. 9–8. 4	High.
CL	A–6	95–100	90–100	60–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
ML	A–4	90–100	85–95	50–75	0. 6–2. 0	0. 14–0. 18	6. 1–6. 5	Low.
ML–CL	A–4	90–100	85–95	50–75	0. 6–2. 0	0. 12–0. 18	6. 1–6. 5	Low.
SP	A–1	50–80	40–80	0–5	>6. 0	0. 02–0. 04	7. 4–7. 8	Low.
OL	A–6	95–100	85–95	60–75	0. 6–2. 0	0. 14–0. 18	6. 1–6. 5	Moderate.
CL	A–7	95–100	85–95	60–80	0. 2–0. 6	0. 16–0. 18	6. 1–7. 3	High.
CL	A–6	95–100	85–95	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
OL	A–7	95–100	90–100	60–80	0. 2–0. 6	0. 14–0. 18	6. 1–7. 3	Moderate.
CL	A–6	95–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.
OL	A–7	90–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	7. 4–7. 8	High.
ML	A–4	90–100	90–100	80–90	0. 2–0. 6	0. 19–0. 21	7. 9–8. 4	High.
ML	A–4	90–100	90–100	60–90	0. 6–2. 0	0. 18–0. 23	7. 4–7. 8	Moderate.
CL	A–6	90–100	90–100	50–80	0. 6–2. 0	0. 14–0. 18	7. 4–7. 8	Moderate.

TABLE 8.—*Engineering*

[Marsh (Mk) is not rated in this table because the soil material is too variable for reliable evaluation. An asterisk in the first column different properties and limitations, and for this reason it is necessary to follow carefully

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Alluvial land: Af	Fair	Poor	Poor	Poor: water table at depth of less than 2 feet; frequent flooding; variable, poorly sorted material.	Severe: frequent flooding; high water table.	High
Arveson: As	Good	Good: high water table.	Poor: some fine gravel.	Good: good shear strength; fair stability; fair workability; good compaction.	Severe: water table at depth of 2 to 5 feet; occasional flooding; pollution hazard.	High
*Barnes: BaA, BbB2, BbC2, BdB2, BdC. For Langhei part of BbB2, BbC2, BdB2, and BdC, and for Renshaw part of BdB2 and BdC, see their respective series.	Good	Not suitable	Not suitable	Fair: good stability; fair shear strength; moderate shrink-swell potential; medium compressibility.	Slight on slopes of less than 6 percent. Severe on slopes of more than 12 percent.	Moderate
Bearden: Be	Good	Not suitable	Not suitable	Poor to fair: fair shear strength; moderate shrink-swell potential; fair stability; good compaction.	Moderate: moderate permeability; water table occasionally at depth of less than 4 feet.	High
Blue Earth: Bh	Good	Not suitable	Not suitable	Poor: fair shear strength; poor compaction; medium compressibility; moderate shrink-swell potential; good workability.	Severe: high water table.	High
Canisteo: Ca	Fair	Not suitable	Not suitable	Fair: fair shear strength; fair stability; poor workability; fair compaction; moderate shrink-swell potential; medium compressibility.	Severe: high water table; moderate permeability.	High

See footnotes at end of table.

interpretations

indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have the instructions for referring to other series that appear in the first column of this table.]

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Water table at depth of less than 2 feet; frequent flooding; mixed, variable material.	High water table; frequent flooding; good location for dugout pits.	Water table at depth of less than 2 feet; frequent flooding; variable, poorly sorted material.	Frequent flooding; water table at depth of less than 2 feet; outlets difficult to obtain.	(3)	(3)	Frequent flooding; high water table; variable, poorly sorted material.
Poorly drained; high water table; fair stability.	High water table; sandy subsoil; good location for dugout pits.	Moderate permeability; water table at depth of 2 to 5 feet; piping hazard; fair stability; fair workability.	Sand at depth of less than 2 feet; water table at depth of 2 to 5 feet; subject to piping; fine material may plug tile drainage; ditchbanks unstable.	Poorly drained	(3)	Poorly drained; erodible; difficult to vegetate.
Fair workability; medium compressibility; good stability.	Moderate permeability; good compaction.	Good stability; fair shear strength; medium compressibility; moderate shrink-swell potential.	(3)	(3)	Complex slopes	Complex slopes; steep in places.
Fair stability; good compaction; plastic.	Moderate permeability; good compaction.	Fair stability; fair shear strength; medium compressibility; moderate shrink-swell potential.	(3)	(3)	(3)	Calcareous; difficult to vegetate in places.
Very poorly drained; high water table; frequent flooding; medium compressibility.	High water table; high content of organic matter; good location for dugout pits.	Water table at depth of less than 4 feet; high content of organic matter; unstable.	Water table at depth of less than 4 feet; moderate permeability.	(3)	(3)	Very poorly drained; hazard of flooding.
Fair stability; high water table.	Poorly drained; moderate permeability.	Water table at depth of 0 to 4 feet; fair shear strength; moderate shrink-swell potential; medium compressibility.	Water table at surface to depth of 4 feet; moderate permeability.	(3)	(3)	Poorly drained; calcareous.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Clarion: CmB, CmC2	Good	Not suitable	Not suitable	Fair: good stability; medium compressibility; fair shear strength; moderate shrink-swell potential.	Slight on slopes of less than 6 percent. Severe on slopes of more than 12 percent.	Moderate
Clontarf: Cn	Good	Good	Not suitable	Good: good shear strength; low compressibility; good compaction; low shrink-swell potential.	Moderate: seasonal high water table at depth of about 3 feet; pollution hazard.	Low
Colvin:						
Co	Good	Not suitable	Not suitable	Poor to fair: fair shear strength; medium compressibility; fair compaction.	Severe: seasonal high water table at depth of less than 5 feet; moderately slow permeability.	High
Cp	Fair	Not suitable	Not suitable	Poor: high water table; fair shear strength; medium compressibility; poor compaction.	Severe: frequent flooding; water table at depth of less than 2 feet; moderately slow permeability.	High
Darnen: DaB	Good	Not suitable	Not suitable	Poor: fair shear strength; medium compressibility; poor stability; fair workability; poor compaction.	Slight	Moderate
Dickinson: DcA, DcB	Good	Good	Not suitable	Good: good shear strength; low compressibility; good compaction; low shrink-swell potential.	Slight: pollution hazard.	Low

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Good stability; fair workability; good compaction.	Moderate permeability; good compaction.	Good stability; fair shear strength; good compaction.	(3)		Rolling in places.	Slope is more than 6 percent in some places.
Fair stability; hazard of erosion on cuts and fills.	Rapid permeability in sand substratum.	Rapid permeability in substratum; piping hazard; fair stability; fair workability.	(3)	Low available water capacity.	(3)	Erodible; porous.
Poorly drained; water table at depth of 2 to 5 feet; poor stabiliy; medium compressibility; high shrink-swell potential.	Location fair for dugout pits; water table at depth of 2 to 5 feet.	Poor stability; fair compaction; water table at depth of 2 to 5 feet; fair shear strength; high shrink-swell potential; piping hazard.	Water table at depth of 2 to 5 feet; moderately slow permeability; surface and subsurface drainage needed.	(3)	(3)	Poorly drained; calcareous; drainage needed before construction.
Very poorly drained; water table at depth of 0 to 2 feet; poor stability; medium compressibility; high shrink-swell potential; hazard of flooding.	High water table; location good for dugout pits.	Poor stability; poor compaction; water table at depth of 0 to 2 feet; fair shear strength; high shrink-swell potential; piping hazard.	Water table at depth of 0 to 2 feet; frequent flooding; moderately slow permeabillity.	(3)	(3)	Very poorly drained; hazard of flooding; drainage needed before construction.
Poor stability; high content of organic matter.	Moderate permeability.	Poor stability; poor compaction; moderate permeability; piping hazard; fair shear strength.	(3)	(3)	Sometimes used as drainage outlet.	Slopes of more than 2 percent in places.
Fair stability; highly erodible.	Rapid permeability; sandy substratum.	Rapid permeability; piping hazard; fair stability; fair workability.	(3)	Low available water capacity.	(3)	Substratum susceptible to erosion if exposed.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Doland: DlA, DlB	Good	Not suitable	Not suitable	Poor to fair to depth of 2 feet; silty; fair shear strength; fair workability; poor stability.	Slight	Moderate
Estelline:						
Es	Good	Good at depth of 2 to 3 feet.	Good at depth of 2 to 3 feet.	Poor to depth of 30 inches: poor shear strength and compaction. Good in substratum: good shear strength; good compaction; low compressibility.	Slight: pollution hazard.	Low
Et	Good	Good at depth of 2 to 3 feet: mixed sand and gravel.	Good at depth of 2 to 3 feet: mixed sand and gravel.	Poor to a depth of 30 inches: poor shear strength and compaction. Good in substratum: good shear strength; good compaction; low compressibility.	Slight: pollution hazard.	Low
Estherville: EvA, EvB, EvC2, EwA, EwB.	Good	Good at depth of 2 to 3 feet: mixed sand and gravel.	Good at depth of 2 to 3 feet: mixed sand and gravel.	Fair to depth of 20 inches: Good in substratum: good stability; low compressibility.	Slight on level to gentle slopes: seepage hazard on downslope surface. Severe on slopes of more than 12 percent: pollution hazard.	Low
Flandreau: FlA, FlB	Good	Good at depth of 2 to 3 feet.	Poor	Poor to depth of 30 inches: poor shear strength and compaction. Good in substratum: good shear strength; good compaction; low compressibility.	Slight: pollution hazard.	Low

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Poor stability and poor compaction to depth of 2 feet; good compaction and medium compressibility at depth of more than 2 feet.	Moderate permeability; good compaction at depth of more than 2 feet.	Moderate permeability; piping hazard in surface layer; fair shear strength.	(3)	(3)	Rolling in places.	Slopes of more than 2 percent in places.
Poor stability in surface layer; low compressibility and good stability in substratum.	Porous material	Rapid permeability; piping hazard; good shear strength and stability in substratum.	(3)	(4)	Gravelly substratum at depth of 2 to 3 feet.	Gravelly material at depth of 2 to 3 feet; difficult to vegetate in places.
Poor stability in surface layer; medium compressibility and good stability in substratum.	Porous material	Rapid permeability; piping hazard; good shear strength and poor stability in substratum.	(3)	(4)	Gravelly substratum at depth of 2 to 3 feet.	Gravelly material at depth of 2 to 3 feet; difficult to vegetate in places.
Good stability; good compaction; low compressibility.	Porous material	Good stability; good compaction; low compressibility; piping hazard.	(3)	Shallow depth to coarse substratum; low available water capacity.	Sand and gravel at depth of less than 2 feet.	Sand and gravel at depth of less than 2 feet; difficult to vegetate.
Poor stability to depth of 30 inches; medium compressibility and good stability in substratum.	Porous material	Rapid permeability; piping hazard; good shear strength; good stability.	(3)	(4)	Sandy material at depth of 2 to 3 feet.	Sandy material at depth of 2 to 3 feet; difficult to vegetate in places.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
*Flom. Mapped only in complex with soils of the Parnell series.	Good	Not suitable	Not suitable	Fair: poor workability; water table at depth of 2 to 5 feet; fair shear strength; moderate shrink-swell potential.	Severe: high water table; moderately slow permeability.	High.
Fordville: FoA, FoB	Good	Good at depth of 2 to 3 feet: sand and gravel.	Good at depth of 2 to 3 feet: sand and gravel.	Poor at depth of 30 inches: poor shear strength and compaction. Good in substratum: good shear strength; good compaction; low compressibility.	Slight: pollution hazard.	Low.
Forman: FrB2, FrC2	Fair	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair workability; high shrink-swell potential; good compaction.	Severe: moderately slow permeability.	Moderate.
Glencoe: Gn	Fair	Not suitable	Not suitable	Poor: fair shear strength; moderate shrink-swell potential; fair workability; poor compaction.	Severe: frequent flooding; high water table; moderately slow permeability.	High.
Hamar: Hc	Good	Good at depth of 2 to 3 feet.	Poor	Good: high water table; good shear strength; low compressibility; fair stability; fair workability.	Severe: water table at depth of 2 to 4 feet; pollution hazard.	Moderate.
Hamerly: Hd	Good	Not suitable	Not suitable	Fair: fair shear strength; good compaction; medium compressibility; good stability.	Slight	Moderate.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Poorly drained; water table at depth of 2 to 5 feet; moderate shrink-swell potential.	High water table; moderately slow permeability.	Fair stability; water table at depth of 2 to 5 feet; high compressibility; good compaction.	Seasonal high water table at depth of 2 to 5 feet; moderately slow permeability; surface and tile drainage needed.	(3)	(3)	Poorly drained; drainage needed before construction.
Good stability and compaction in substratum.	Porous material	Fair stability; good compaction; low compressibility; piping hazard.	(3)	(4)	Gravelly substratum at depth of 2 to 3 feet.	Gravelly substratum at depth of 2 to 3 feet; difficult to vegetate in places.
Fair stability; medium compressibility.	Moderately slow permeability; good compaction.	Fair stability; high shrink-swell potential; medium compressibility.	(3)	(3)	Moderately slow permeability; rolling in places.	Slope is more than 2 percent in places.
Fair stability; very poorly drained; water table at depth of less than 2 feet; frequent flooding; medium compressibility.	High water table; good location for dugout pits.	Fair stability; water table at depth of less than 2 feet; fair shear strength; moderate shrink-swell potential.	Water table at depth of less than 2 feet; frequent flooding; moderately slow permeability.	(3)	(3)	Very poorly drained; hazard of flooding.
Water table at depth of less than 4 feet: poorly drained; fair stability; high erodibility.	Rapid permeability; high water table; good location for dugout pits.	Rapid permeability; water table at depth of 2 to 4 feet; piping hazard; fair stability; fair workability.	Sand substratum at depth of 2 feet; water table at depth of 2 to 4 feet, fine material may plug tile drains; ditchbanks unstable.	Poorly drained	(3)	Sand substratum; poorly drained.
Good stability; good compaction.	Moderate permeability.	Good stability; good compaction; medium compressibility.	(3)	(3)	Undulating; calcareous.	Calcareous; difficult to vegetate.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Hecla: Hv	Poor	Good	Poor	Good: good shear strength; low compressibility; fair workability; good compaction.	Moderate: seasonal high water table at depth of less than 4 feet; pollution hazard.	Low
Lake beaches:						
La	Poor	Good: high water table.	Poor: high water table.	Poor: poorly drained; frequently flooded.	Severe: pollution hazard; high water table.	Low
Lb	Good	Not suitable	Not suitable	Fair: fair stability; medium compressibility; fair workability; fair compaction.	Severe: frequent flooding; water table at depth of less than 2 feet.	High
Lamoure:						
Lc, Lk	Good	Not suitable	Not suitable	Poor: poor stability; poor shear strength; medium compressibility; fair workability.	Severe: water table at depth of less than 5 feet.	High
Lh	Good	Not suitable	Not suitable	Poor: poor shear strength; poor workability; high water table.	Severe: frequent flooding; water table at depth of less than 2 feet.	High
Langhei:						
*LlE, LlF, LnB2, LnC2, LnD2, LoD2. For Barnes part of LnB2, LnC2, LnD2, and LoD2, and for Sioux part of LoD2, see their respective series.	Fair	Not suitable	Not suitable: small pockets of gravel in places.	Fair: fair shear strength; good compaction; medium compressibility.	Slight on slopes of less than 6 percent. Severe on slopes of more than 12 percent: hazard of seepage on downslope surface.	Moderate
LmF	Fair	Not suitable	Not suitable: small pockets of gravel in places.	Not suitable: stony.	Severe: stoniness; surface seepage downslope on slopes of more than 2 percent.	Moderate

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Poor stability; high erodibility.	Rapid permeability; sand substratum.	Rapid permeability; piping hazard; poor stability; fair workability.	(3)	Very low available water capacity.	(3)	Susceptible to erosion; droughty; difficult to vegetate.
Water table at depth of less than 3 feet; hazard of flooding; poor stability; high erodibility.	Hazard of flooding; good location for dugout pits.	High water table; rapid permeability; poor stability.	Unstable material; water table at depth of less than 2 feet; outlets difficult to obtain.	(3)	(3)	Hazard of flooding; coarse-textured subsoil.
Fair stability; high water table; hazard of flooding.	High water table; good location for dugout pits.	Water table at depth of less than 2 feet; fair shear strength; fair stability.	Water table at depth of less than 2 feet; outlets difficult to obtain.	(3)	(3)	Hazard of flooding; very poorly drained.
Poor stability; high water table; hazard of flooding.	Water table at depth of 2 to 5 feet; good location for dugout pits.	Water table at depth of 2 to 5 feet; poor shear strength; poor stability.	Moderate permeability; water table at depth of 2 to 5 feet; outlets difficult to obtain.	(3)	(3)	Poorly drained; hazard of flooding.
Poor stability; hazard of flooding.	High water table; good location for dugout pits.	Poor stability; fair compaction; hazard of flooding; medium compressibility.	Frequent flooding; water table at depth of less than 2 feet; moderate permeability; outlets difficult to obtain.	(3)	(3)	Frequently flooded; very poorly drained.
Good stability; steep; stones and boulders in places.	Moderate permeability; good compaction.	Good stability; fair shear strength.	(3)	(3)	Complex slopes; steep in places; calcareous subsoil.	Slope is more than 2 percent in most places; difficult to vegetate; calcareous.
Contains many stones and boulders.	Moderate permeability; good compaction.	Good stability; fair shear strength; stoniness hinders construction.	(3)	(3)	Rolling to steep; stoniness hinders construction.	Stoniness; steep.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Maddock: MbC, MbE, MdA, MdB.	Fair	Good	Not suitable	Good: good shear strength; low compressibility; fair workability; low shrink-swell potential; poor stability.	Slight: level to gently sloping: pollution hazard. Severe on slopes of more than 12 percent: hazard of seepage on downslope surface.	Low
Malachy: Mf	Good	Good	Poor	Good: good shear strength; low compressibility; fair workability; low shrink-swell potential; fair stability.	Moderate: seasonal high water table at depth of less than 4 feet; pollution hazard.	Low
Marysland: Ml	Good	Good at depth of 2 to 3 feet: high water table; mixed sand and gravel.	Good at depth of 2 to 3 feet: high water table; mixed sand and gravel.	Poor to depth of substratum: poor shear strength. Good in substratum: low compressibility.	Severe: water table at depth of 2 to 5 feet; pollution hazard.	High
Mayer: Mn	Good	Good at depth of 2 to 3 feet: mixed sand and gravel; high water table.	Good at depth of 2 to 3 feet: mixed sand and gravel; high water table.	Poor in surface layer: poor shear strength. Good in substratum: low compressibility.	Severe: water table at depth of 0 to 5 feet; pollution hazard.	High
Mo	Good	Fair at depth of 2 to 3 feet: mixed sand and gravel; high water table.	Fair at depth of 2 to 3 feet: mixed sand and gravel; high water table.	Poor in surface layer: poor shear strength. Good in substratum: low compressibility; water table at depth of less than 2 feet.	Severe: frequent flooding; pollution hazard.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—							
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Poor stability; high erodibility.	Rapid permeability; porous substratum.	Rapid permeability; piping hazard; poor stability; fair workability.	(3)	Low available water capacity; slopes more than 12 percent in some places.	Sandy subsoil; susceptible to erosion; difficult to vegetate.	Sandy subsoil susceptible to erosion; difficult to vegetate.
Fair stability; medium erodibility.	Rapid permeability; porous subtratum.	Rapid permeability; piping hazard; fair stability; fair workability.	(3)	Low available water capacity.	(3)	Substratum susceptible to erosion; difficult to vegetate.
Fair stability; high water table.	High water table; rapid permeability; good location for dugout pits.	Water table at depth of 2 to 5 feet; poor shear strength above depth of 2 to 3 feet; rapid permeability; fair stability and piping hazard in substratum.	Sand and gravel at depth of 2 to 3 feet; water table at depth of 2 to 5 feet; ditchbanks unstable.	(3)	(3)	Poorly drained; highly calcareous subsoil; sand at depth of 2 to 3 feet.
Fair stability; high water table.	High water table; rapid permeability; good location for dugout pits.	Water table at depth of 0 to 5 feet; poor shear strength to depth of 2 to 3 feet; rapid permeability, fair stability, and piping hazard in substratum.	Sand and gravel at depth of 2 to 3 feet; water table at depth of 0 to 5 feet; ditchbanks unstable.	(3)	(3)	Poorly drained; gravelly substratum at depth of 2 to 3 feet.
Fair stability; high water table at depth of less than 2 feet.	High water table; rapid permeability; good location for dugout pits.	Water table at depth of less than 2 feet; poor shear strength to depth of 2 to 3 feet; rapid permeability, fair stability, and piping hazard in substratum.	Water table at depth of less than 2 feet; frequent flooding; ditchbanks unstable; gravel and sand at depth of 2 to 4 feet.	(3)	(3)	Very poorly drained; hazard of flooding.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Mayer—Continued Mr	Good	Fair at depth of 2 to 3 feet: mixed sand and gravel; high water table.	Poor	Poor in surface layer: poor shear strength. Good in substratum: low compressibility; water table at depth of less than 2 feet.	Severe: frequent flooding; pollution hazard.	High
McIntosh: Ms	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair workability; poor stability; moderate shrink-swell potential.	Slight	High
Muck: Mt	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High
Muck, calcareous: Mu	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High
Muck, calcareous, seeped: Mv	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High
Muck, calcareous, over loam: Mw.	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Fair stability; high water table at depth of less than 2 feet.	High water table; rapid permeability; good location for dugout pits.	Water table at depth of less than 2 feet; poor shear strength to depth of 2 to 3 feet; rapid permeability, fair stability, and piping hazard in substratum.	Water table at depth of less than 2 feet; frequent flooding; ditchbanks unstable; gravel and sand at depth of 2 to 4 feet.	(3)	(3)	Very poorly drained; hazard of flooding.
Poor stability; fair to good compaction.	Moderate permeability.	Moderate permeability; poor to fair resistance to piping; fair shear strength.	(3)	(3)	Calcareous	Calcareous; difficult to vegetate in places.
Organic material; not suitable for construction.	High water table; good location for dugout pits.	Organic material; not suitable for construction.	Water table at depth of less than 2 feet; uneven settling of organic material is hazardous to tile drains; ditchbanks unstable.	(3)	(3)	Unstable material; very poorly drained; hazard of flooding.
Organic material; not suitable for construction.	High water table; good location for dugout pits.	Organic material; not suitable for construction.	Water table at depth of less than 2 feet; uneven settling of organic material is hazardous to tile drains; ditchbanks unstable.	(3)	(3)	Unstable material; very poorly drained; hazard of flooding.
Water table at depth of less than 2 feet; unstable material.	High water table; good location for dugout pits.	High water table; very poor stability.	Water table at depth of less than 2 feet; unstable material.	(3)	(3)	Wetness; unstable material.
Organic material; not suitable for construction.	High water table; good location for dugout pits.	Organic material; not suitable for construction.	Water table at depth of less than 2 feet; unstable organic material settles unevenly; tile should be laid in loam if possible.	(3)	(3)	Unstable material; very poorly drained; hazard of flooding.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Muck, calcareous, over sand: Mx.	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High
Muck over loam: My	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High
Muck over sand: Mz	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: water table at depth of less than 2 feet.	High
Nicollet: Nc	Good	Not suitable	Not suitable	Fair: good stability; medium compressibility; fair shear strength; moderate shrink-swell potential.	Slight	Moderate
Nutley: NuA, NuB	Fair	Not suitable	Not suitable	Poor: poor shear strength; high shrink-swell potential; poor workability; high compressibility.	Severe: very slow permeability.	Moderate

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Organic material; not suitable for construction.	High water table; good location for dugout pits.	Organic material; not suitable for construction.	Water table at depth of less than 2 feet; sand substratum at depth of 18 to 40 inches; hazard that material will plug or cause uneven grade in tile drains; ditchbanks unstable.	(3)	(3)	Unstable material; very poorly drained; hazard of flooding.
Organic material; not suitable for construction.	High water table; good location for dugout pits.	Organic material; not suitable for construction.	Water table at depth of less than 2 feet; unstable; organic material settles unevenly; tile should be laid in loam if possible.	(3)	(3)	Unstable material; very poorly drained; hazard of flooding.
Organic material; not suitable for construction.	High water table; good location for dugout pits.	Organic material; not suitable for construction.	Water table at depth of less than 2 feet; sand substratum at depth of 18 to 40 inches; hazard that material will plug or cause uneven grade in tile drains; ditchbanks unstable.	(3)	(3)	Unstable material; very poorly drained; hazard of flooding.
Good stability; fair workability; good compaction.	Moderate permeability; good compaction.	Fair shear strength; good stability; good compaction.	(3)	(3)	(4)	(4).
Poor stability; fair to poor compaction; high compressibility.	Very slow permeability; high shrink-swell potential.	Fair to poor compaction; high compressibility; poor shear strength; high shrink-swell potential; poor workability.	(3)	(3)	Very slow permeability.	Slopes are more than 2 percent in places.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Oldham: Om	Good	Not suitable	Not suitable	Poor: fair shear strength; medium compressibility; fair workability; high shrink-swell potential.	Severe: frequent flooding; moderately slow permeability; high water table.	High
Osakis: Os	Good	Fair: mixed sand and gravel.	Good: mixed sand and gravel.	Fair to depth of 20 inches; good in substratum: good shear strength; low compressibility; good workability.	Slight: pollution hazard.	Low
Parnell: Pa	Good	Not suitable	Not suitable	Poor: poor shear strength; high compressibility; fair workability; high shrink-swell potential.	Severe: frequent flooding; moderately slow permeability; high water table.	High
Parnell and Flom: Pf	Good	Not suitable	Not suitable	Poor: poor shear strength; high compressibility; fair workability; moderate to high shrink-swell potential.	Severe: moderately slow permeability; water table at depth of less than 4 feet.	High
Perella: Pr	Good	Not suitable	Not suitable	Poor: poor shear strength; medium compressibility; fair workability; high shrink-swell potential.	Severe: seasonal high water table at depth of less than 4 feet; moderately slow permeability.	High
Renshaw: ReA, ReB, ReC2	Good	Fair: mixed sand and gravel.	Good: mixed sand and gravel.	Fair to depth of 20 inches. Good in substratum: good shear strength; low compressibility; good workability.	Slight: pollution hazard.	Low

See footnotes at end of table.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
Fair stability; high water table; frequent flooding.	High water table; good location for dugout pits.	Water table at depth of less than 3 feet; fair shear strength; high shrink-swell potential; fair stability.	Wet; depressional; surface and subsurface drainage needed; moderately slow permeability; tile drains should have surface inlets.	(3)	(3)	Poorly drained; hazard of flooding; drainage needed before construction.
Good stability; good compaction.	Rapid permeability; porous in substratum.	Good stability; good compaction; low compressibility.	(3)	Shallow depth to sand and gravel substratum; low available water capacity.	(3)	Gravel substratum at depth of less than 2 feet; difficult to vegetate.
Fair stability; high water table; frequent flooding.	High water table; good location for dugout pits.	Wet table at depth of less than 3 feet; poor shear strength; high compressibility; high shrink-swell potential; poor workability.	Wet; depressional; surface and subsurface drainage needed; moderately slow permeability; tile drains should have surface inlets.	(3)	(3)	Very poorly drained; hazard of flooding; drainage needed before construction.
Fair stability; high water table.	High water table; moderately slow permeability.	Fair to poor compaction; high compressibility; water table at depth of 2 to 4 feet; poor shear strength; moderate to high shrink-swell potential; fair workability.	Water table at depth of 2 to 4 feet; moderately slow permeability; surface and subsurface drainage needed; seasonal high water table.	(3)	(3)	Poorly drained; fine-textured subsoil; drainage needed before construction.
Poor stability; high water table.	High water table	Water table at depth of 2 to 4 feet; poor shear strength; poor stability; fair compaction; high shrink-swell potential.	Seasonal high water table at depth of 2 to 4 feet; moderately slow permeability; surface and subsurface drainage needed.	(3)	(3)	Poorly drained; hazard of flooding; drainage needed before construction.
Good stability; good compaction.	Rapid permeability below depth of 20 inches; porous.	Good ststability; good compaction; low compressibilty.	(3)	Shallow depth to sand and gravel substratum; low available water capacity; sloping in places.	Sand and gravel at depth of less than 2 feet.	Gravelly substratum at depth of less than 2 feet; difficult to vegetate.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Salida: SdB, SdC2, SeF	Poor	Fair	Good	Good: good shear strength; good workability; low compressibility; good compaction.	Slight: pollution hazard. Severe on slopes of more than 12 percent; hazard of seepage on downslope surfaces.	Low
Sioux: SlB, SlC2, SoF	Poor	Fair	Good	Good: good shear strength; good workability; low compressibility; good compaction.	Slight: pollution hazard. Severe on slopes of more than 12 percent.	Low
*Storden: SrE2. For Clarion part of SrE2, see Clarion series	Fair	Not suitable	Not suitable: small pockets of gravel in places.	Fair: fair shear strength; good compaction; medium compressibility.	Slight on slopes of not more than 6 percent. Severe on slopes of more than 12 percent: hazard of seepage on downslope surfaces.	Moderate
Svea: SuA, SuB	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair compaction; good stability; moderate shrink-swell potential.	Slight	Moderate
Sverdrup: SyB2, SyC2, SzA	Good	Good: mixed sand and gravel.	Poor: mixed sand and gravel.	Good: good shear strength; low compressibility; fair workability.	Slight: pollution hazard.	Low
Tara: Ta	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair workability; fair compaction.	Slight	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—							
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Good stability; low compressibility.	Rapid permeability below depth of 8 inches; porous in substratum.	Rapid permeability; good stability; good compaction.	(3)	Very low available water capacity; steep in places.	Sand and gravel at depth of less than 1 foot; steep in places.	Gravelly substratum at depth of less than 1 foot; difficult to vegetate.
Good stability; low compressibility.	Rapid permeability below depth of 8 inches; porous in substratum.	Rapid permeability; good stability; good compaction.	(3)	Very low available water capacity; steep in places.	Sand and gravel at depth of less than 1 foot; steep in places.	Gravelly substratum at depth of less than 1 foot; difficult to vegetate.
Good stability; steep; contains stones and boulders in places.	Moderate permeability; good compaction.	Fair shear strength; good stability.	(3)	(3)	Steep, complex slopes; calcareous subsoil.	More than 2 percent slopes in most places; difficult to vegetate; calcareous.
Good stability; fair compaction.	Moderate permeability; highly impervious if compacted.	Good stability; fair compaction; medium compressibility; moderate shrink-swell potential.	(3)	(3)	(4)	Fair stability; all features favorable.
Fair stability; good compaction.	Rapid permeability at depth of 20 inches; porous in substratum.	Fair stability rapid permeability; piping hazard.	(3)	Low available water capacity; steep in places.	Sandy substratum; susceptible to erosion; difficult to vegetate; steep in places.	Sandy material at depth of less than 2 feet; difficult to vegetate; susceptible to erosion.
Fair to poor stability; fair compaction.	Moderate permeability; piping hazard.	Moderate permeability; hazard of piping in surface layer; fair shear strength; poor to fair stability.	(3)	----------	(4)	Fair to poor stability.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as source of—				Limitations for septic tank filter fields	Susceptibility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Tonka: To	Good	Not suitable	Not suitable	Poor: poor shear strength; high compressibility; poor workability; high shrink-swell potential; fair compaction.	Severe: very slow permeability; frequent flooding.	High
Vallers: Va	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair workability; moderate to high shrink-swell potential; fair compaction.	Severe: water table at depth of less than 4 feet; moderately slow permeability.	High
Wadena: Wa	Good	Fair at depth of 2 to 3 feet: mixed sand and gravel.	Good at depth of 2 to 3 feet: mixed sand and gravel.	Fair to depth of 2 feet: fair shear strength; low compressibility; fair workability. Good in substratum: good shear strength; fair compaction.	Slight: pollution hazard.	Low
Waukon: WbA, WbB, WbC, WbD, WdB2, WdC2.	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair workability; high shrink-swell potential; good compaction.	Severe: moderately slow permeability in subsoil; hazard of seepage on downslope surfaces of slopes of more than 12 percent.	Moderate
Webster: We	Fair	Not suitable	Not suitable	Fair: poor workability; fair shear strength; moderate shrink-swell potential; medium compressibility.	Severe: water table at depth of less than 4 feet; moderately slow permeability.	High
Winger: Wn	Good	Not suitable	Not suitable	Fair: poor workability; fair shear strength; moderate to high shrink-swell potential; medium compressibility.	Severe: water table at depth of less than 4 feet; moderately slow permeability.	High

[1] Refers to the surface layer only.
[2] Refers to the substratum or underlying material unless otherwise specified.

interpretations—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways
	Reservoir area	Embankment				
Fair stability; hazard of flooding; high shrink-swell potential.	High water table; hazard of flooding; good location for dugout pits.	Water table at depth of less than 4 feet; high compressibility; poor shear strength; high shrink-swell potential; poor workability.	Seasonal high water table at depth of less than 4 feet; frequent flooding; very slow permeability; surface and subsurface drainage needed.	(3)	(3)	Very poorly drained; hazard of flooding.
Good stability; high water table.	High water table; moderately slow permeability.	Water table at depth of 2 to 4 feet; fair shear strength; moderate to high shrink-swell potential; good stability.	Water table at depth of 2 to 4 feet; moderately slow permeability; surface and subsurface drainage needed.	(3)	(3)	Poorly drained; calcareous; drainage needed before construction.
Good stability; fair compaction.	Porous substratum.	Good stability; fair compaction; low compressibility; piping hazard.	(3)	(4)	(3)	Gravel substratum at depth of 2 to 3 feet; difficult to vegetate in places.
Fair stability; good compaction.	Moderately slow permeability; highly impervious where compacted.	Medium compressibility; fair shear strength; high shrink-swell potential.	(3)	(3)	Moderately slow permeability; complex slopes; steep in places.	Most slopes are more than 2 percent; heavy clay loam subsoil.
Fair stability; seasonal water table; medium compressibility; moderate shrink-swell potential.	Moderately slow permeability; high water table.	Water table at depth of 2 to 4 feet; fair shear strength; moderate shrink-swell potential.	Water table at depth of 2 to 4 feet; moderately slow permeability; surface and subsurface drainage needed.	(3)	(3)	Poorly drained.
Fair stability; seasonal high water table; medium compressibility; moderate shrink-swell potential.	Moderately slow permeability; high water table.	Water table at depth of 2 to 4 feet; fair shear strength; moderate shrink-swell potential.	Water table at depth of 2 to 4 feet; moderately slow permeability; surface and subsurface drainage needed.	(3)	(3)	Poorly drained.

3 Practice is generally not applied to this soil.
4 All features favorable.

424-010—72——8

Engineering interpretations

Table 8 rates the soils according to their suitability as a source of topsoil, sand, gravel, and road fill. It also gives soil features that affect the use of soils for sewage disposal systems, highway location, farm ponds, and agricultural engineering.

The suitability ratings for topsoil, sand, and gravel apply only to the survey area. Some soils are rated fair or poor as a source of topsoil because they are eroded, low in content of organic matter, or low in natural fertility; or because they have a surface horizon that is sticky and difficult to work. The soils rated as good sources of sand will need further examination if material meeting certain gradation requirements is required.

Ratings for suitability of the soils as road fill apply only to materials below the surface layer. Generally, the soils were rated according to their AASHO classifications. Sandy soils A–1, A–2, or A–3 are good; loamy soils A–4 or A–5 are fair; clayey soils A–6 or A–7 are poor; and organic soils are poor. The significant soil features affecting the suitability for road fill are also rated.

In rating soils for susceptibility to frost action, the texture of the surface layer and subsoil were the main features considered. Layers that contain a high percentage of silt are the most susceptible to frost action. Frost boils or heaves are a serious problem in Pope County. Frost heaving is caused by ice crystals developing in the soil. In this process water in thin films moves toward the ice crystal, freezes at the edge of it, and causes it to increase in size. Silt-size particles will support a continual flow of films of water, but particles the size of sand are too large to support this flow. Frost heaves result in spring from differential thawing of soil material inplace or at construction sites where materials with different expansion rates are used. The high water table of many soils also is a factor contributing to frost heaving.

The features considered for highway location were those that affect the overall performance of the soil for the location of highways. The evaluation for the entire soil profile was based on undisturbed soil without artificial drainage. It was assumed that the surface layer is removed in construction and used for topsoil. Engineers intereseted in highway location also should refer to the ratings for road fill and to susceptibility to frost action.

The suitability of soils for septic tank filter fields is important if residential and industrial developments must depend on septic tank disposal systems. In table 8 the soils have been rated as slight, moderate, or severe according to the degree of limitation. Among the features that affect the use of a soil for a septic tank filter field are slope, permeability, seepage, depth to the water table, presence of stones and boulders, and hazard of flooding. It should be noted that soil variations may occur within a short distance, and in order to predict the suitability of a specific site, onsite inspection and evaluation may be needed. Although soils that have rapid permeability have slight limitation for filter fields, it should be noted that there is a hazard of contaminating water supplies, streams, ponds, and lakes if seepage from the filter fields enters the water source.

Good sites for farm ponds are available in the county. Deep drainageways that have steep side slopes, such as those in Langhei soils, make good reservoir areas. The seepage rate in Langhei soils is slow, and the glacial till that underlies these soils is suitable for use in embankments. Before selecting a site for a pond, borings should be made in the reservoir areas to determine if underlying sand or gravel layers are present. The soil features for road fill also apply to embankments.

Good locations for dugout pits are in the very poorly drained depressional soils. The soil should have a high water table that is easily exposed by digging the pit (fig. 13). Poorly drained and very poorly drained soils that have a sand or gravel substratum are well suited to dugout pits, because a more constant water level is maintained by the unrestricted lateral movement of water in the porous substratum. Examples of soils that have a sand substratum are those of the Marysland, Arveson, and Hamar series. Dugout pits constructed in medium-textured or fine-textured soils such as the Parnell, Oldham, Glencoe, or Colvin, depressional phase, also should be located where they will catch and hold runoff.

Soils that are wet and have poor natural drainage require some form of artificial drainage for good crop growth. Surface and subsurface drainage are needed on the very poorly drained depressional soils, such as the Parnell, Oldham, Glencoe, and Perella, depressional phase. Poorly drained soils such as the Colvin, Flom, Canisteo, Webster, and Vallers can be cultivated after the surface has been artificially drained. However, lower crop yields are common on these soils in seasons when rainfall is greater than normal, and tile drainage is needed to lower the water table and eliminate wetness. Many poorly drained soils, such as the Marysland and Arveson, have a sand substratum. Special precautions are required where tile is installed in these soils because there is a hazard of ditchbank cave-in and of the sand flowing into and plugging the tile. Suitable drainage outlets often are difficult to obtain, particularly in bottom lands.

Terraces provide water management and erosion control on slopes of less than 12 percent. Where slopes are irregular, such as on the Barnes-Langhei soils, cutting and filling generally are needed for good alinement of terraces. Compaction is likely to be a problem in the terrace channels if terraces are constructed in spring. If terraces are constructed in fall, compaction is less severe because freezing and thawing before the next growing season improve soil structure. Diversion terraces mainly are used on slopes of more than 12 percent.

Grassed waterways provide drainageways that safely remove excess water and reduce the loss of soil. Among the soil features affecting grassed waterways are fertility, slope, drainage, erodibility, depth to the subsoil or substratum, soil reaction, depth to the water table, and the hazard of flooding.

Formation and Classification of the Soils

This section consists of two main parts. The first part relates the five factors of soil formation to the soils in Pope County with particular emphasis on the parent materials. The second part deals with the classification of the soils.

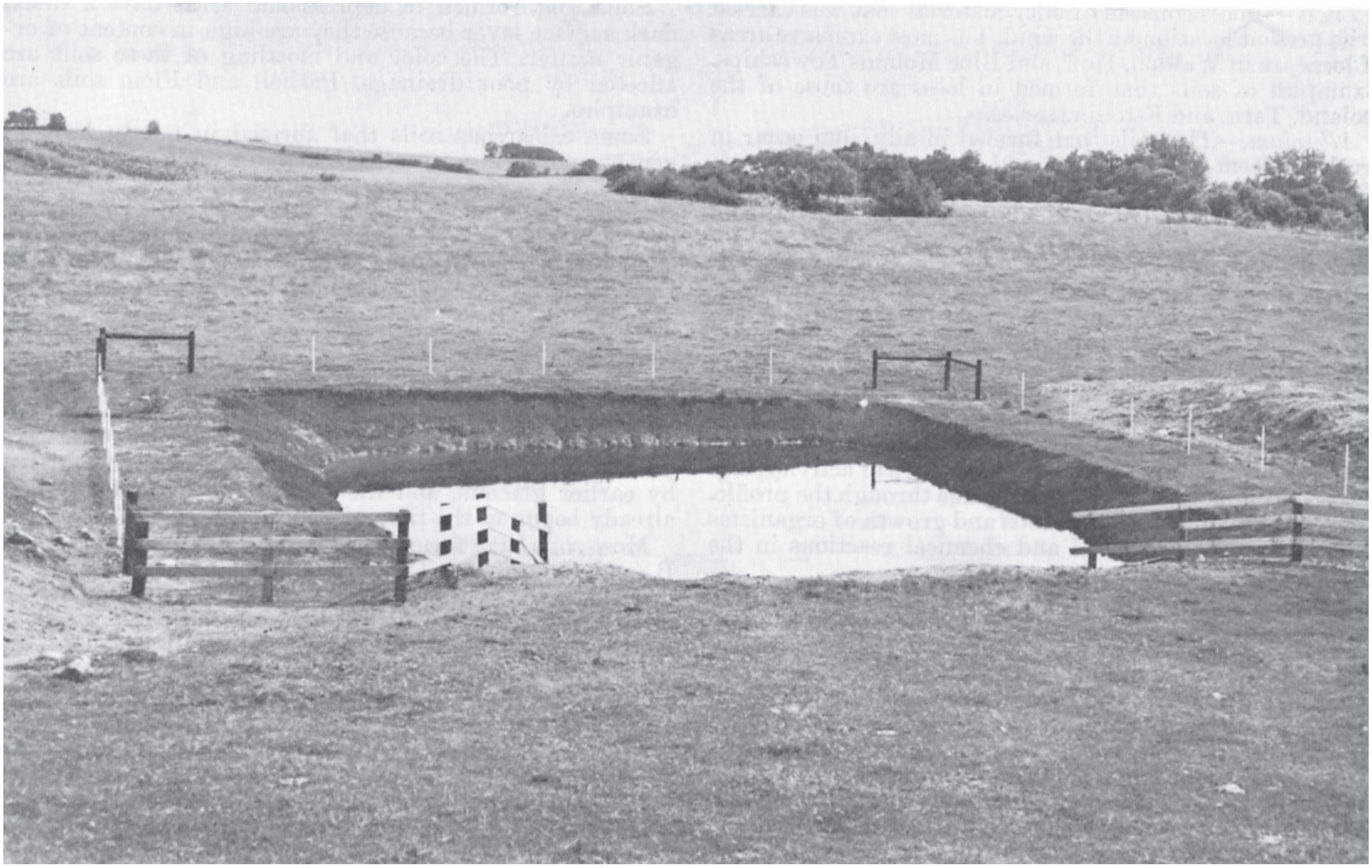

Figure 13.—Stock watering pit in Parnell-Flom soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming process on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent materials; the climate under which the soil material has accumulated and existed since accumulation; and plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the processes of soil formation have acted on the soil material.

Climate and vegetation are active factors of soil formation. They act on the parent material and slowly change it into a natural body that consists of genetically related layers, called horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of soil that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil. It may be much or little, but some time is always required for formation of soil horizons. In most soils a long time is required for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Some of the processes of soil formation are unknown.

Parent material

The soils in Pope County formed in glacial drift and modified glacial drift from the Des Moines lobe of the late Wisconsin Glaciation. The Des Moines lobe covered Pope County about 10,000 years ago. When it receded it left behind a thick mantle of glacial drift. Melt water from the glacier flowed out over much of the county and modified the glacial drift to lacustrine and outwash sediments.

Glacial till.—About two-thirds of the soils in Pope County formed in glacial till. The soils that formed in the glacial till are a mixture of sand, silt, and clay and are mainly loam in texture. Small pebbles and stones are distributed throughout the profile. The parent material is about the same today as it was when the glacier deposited it. The principal glacial till soils are the Barnes, Canisteo, Hamerly, Langhei, Parnell, Svea, and Vallers series.

Outwash.—About one-third of the soils in Pope County formed in outwash material, which is glacial till that has been reworked and deposited by moving water. There are two main areas of outwash in Pope County. The largest area is east of Glenwood in the Estherville-Muck association; the other is in the southwestern part of the county in the Renshaw-Estelline and the Marysland-Muck-Arveson associations. Soils that formed in outwash material consist mainly of sand and gravel. The main outwash soils are those of the Estherville, Renshaw, and Fordville series.

Loess.—Loess consists of silty material that was carried to its present location by the wind. The most extensive areas of loess are in Waldon, Hoff, and Blue Mounds Townships. Examples of soils that formed in loess are those of the Doland, Tara, and Estelline series.

Alluvium.—The soils that formed in alluvium occur in areas adjacent to the rivers and streams in the county. These deposits are relatively recent, and the soils show little development. Lamoure silt loam is an alluvial soil.

Climate

Climate is an active factor in soil formation. It affects the physical, chemical, and biological relationships in the soil profile, primarily through the influence of precipitation and temperature. The amount of water that filters through the soil at a given point depends upon the amount and intensity of rainfall, relative humidity, length of the frost-free period, soil permeability, and physiography. Water dissolves minerals, supports biological activity, and transports mineral and organic residue through the profile. Temperature influences the kinds and growth of organisms and the speed of physical and chemical reactions in the soil.

Plant and animal life

Plants and animals are active factors in the soil-forming processes. Bacteria, fungi, earthworms, and other forms of animal life aid in the breakdown of parent materials and in the decomposition of organic matter. Vegetation affects soil formation by leaving residue in the soil and by transferring plant nutrients from the subsoil to the surface horizon. The kinds of plants and animals that live on and in the soil are determined by the climate, the parent material, relief, and the age of the soil.

The development of the soils in Pope County has been influenced by prairie grasses and forests. Soils that formed under prairie grasses have a dark-colored surface layer that is high in content of organic matter. Soils that formed under trees or shrubs have a moderately dark colored surface layer and a subsoil that is finer textured than the surface layer or the parent material. Barnes soils are an example of soils that formed under prairie grasses, and Waukon soils are an example of soils that formed under forests.

Relief

Relief, through its effect upon drainage, aeration, and erosion, is an important factor in the formation of soils. Maximum profile development takes place in well-drained, gently sloping soils.

In Pope County the effect of relief is most evident in the rolling to hilly morainic areas. Here the steep slopes and hilltops are occupied by soils that have a thin A horizon and are directly underlain by the calcareous parent material. Because these soils are so steep, vegetation has been sparse, erosion has been active, and the supply of moisture has been deficient because the rainfall was lost through runoff. For these reasons, no B horizon has formed. Langhei soils are an example.

On the lower slopes, where soil development has been greater, the soils have a thick, black A horizon, a brownish B horizon, and a greater depth to lime. Barnes soils are an example.

Soils that formed in depressional areas have a thick, dark surface layer because they are high in content of organic matter. The color and mottling of these soils are affected by poor drainage. Parnell and Flom soils are examples.

Some calcareous soils that formed in nearly level to gently undulating areas have a water table within a few feet of the surface. They have a thin, black, calcareous surface layer underlain by a thick, grayish, strongly calcareous layer. While these soils were forming, moisture evaporated from the ground surface, which concentrated lime in the surface layer. Hamerly soils are an example.

Time

The soils in Pope County are all young. The processes of soil formation began about 8,000 years ago, when the glaciers receded. Soils formed in the glacial till in a relatively short time, because most of the soil material deposited by the glacier consisted of reworked drift carried by earlier glaciers, and the weathering of minerals had already begun at the time of deposition.

Most soils that formed in glacial drift have distinct A, B, and C horizons. The development of horizons is less distinct in the poorly drained soils, since a high or fluctuating water table has modified the effect of time. Bottomland soils that occur near rivers and small streams show little development, because the soil material is very young.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of lands.

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and later revised (*5*). The system currently used was adopted by the National Cooperative Soil Survey in 1965. It is under continual study (*6*). Therefore, readers interested in developments of the current system should search the latest literature available (*4*). The soil series of Pope County are placed in some categories of the current system in table 9.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar origin are grouped together. The classes of the current system are briefly defined in the paragraphs that follow.

TABLE 9.—*Classification of soil series*

Series	Family	Subgroup	Order
Arveson	Coarse-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Barnes	Fine-loamy, mixed, frigid	Udic Haploborolls	Mollisols.
Bearden	Fine-silty, mixed, frigid	Aeric Calciaquolls	Mollisols.
Blue Earth [1]	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Canisteo [1]	Fine-loamy, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Clarion [1]	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Clontarf	Coarse-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols.
Colvin	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols.
Darnen	Fine-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols.
Dickinson [1]	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Doland	Fine-silty, mixed, frigid	Udic Haploborolls	Mollisols.
Estelline [2]	Fine-silty over sandy or sandy-skeletal, mixed, frigid.	Pachic Udic Haploborolls	Mollisols.
Estelline, moderately well drained variant.	Fine-silty over sandy or sandy-skeletal, mixed, frigid.	Pachic Udic Haploborolls	Mollisols.
Estherville [1]	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols.
Flandreau [1 3]	Fine-loamy, mixed, mesic	Typic Haplustolls	Mollisols.
Flom	Fine-loamy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Fordville	Fine-loamy over sandy or sandy-skeletal, mixed, frigid.	Udic Haploborolls	Mollisols.
Forman	Fine-loamy, mixed, frigid	Typic Argiborolls	Mollisols.
Glencoe [1]	Fine-loamy, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Hamar	Sandy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Hamerly	Fine-loamy, mixed, frigid	Aeric Calciaquolls	Mollisols.
Hecla	Sandy, mixed, frigid	Pachic Udic Haploborolls	Mollisols.
Lamoure	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols.
Langhei	Fine-loamy, mixed, calcaerous, frigid	Typic Udorthents	Entisols.
Maddock [4]	Sandy, mixed, frigid	Entic Haploborolls	Mollisols.
Malachy	Coarse-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols.
Marysland	Fine-loamy over sandy or sandy-skeletal, mixed, frigid.	Typic Calciaquolls	Mollisols.
Mayer [1]	Fine-loamy over sandy or sandy-skeletal, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols.
Mayer, sandy subsoil variant.	Fine-loamy over sandy or sandy-skeletal, mixed, noncalcareous, frigid.	Typic Haplaquolls	Mollisols.
McIntosh	Fine-silty, mixed, frigid	Aeric Calciaquolls	Mollisols.
Muck	Euic, frigid	Typic Borohemists	Histosols.
Muck, calcareous	Calcareous, frigid	Typic Borosaprists	Histosols.
Muck, calcareous, over loam.	Calcareous, loamy, frigid	Terric Borosaprists	Histosols.
Muck, calcareous, over sand.	Calcareous, sandy, frigid	Terric Borosaprists	Histosols.
Muck over loam	Euic, loamy, frigid	Terric Borosaprists	Histosols.
Muck over sand	Euic, sandy, frigid	Terric Borosaprists	Histosols.
Nicollet [1]	Fine-loamy, mixed, mesic	Aquic Hapludolls	Mollisols.
Nutley [5]	Very fine, montmorillonitic, frigid	Vertic Haploborolls	Mollisols.
Oldham [5]	Fine, montmorillonitic, calcareous, frigid	Cumulic Haplaquolls	Mollisols.
Osakis	Coarse-loamy over sandy or sandy-skeletal, mixed, frigid.	Aquic Haploborolls	Mollisols.
Parnell	Fine, mixed, noncalcareous, frigid	Typic Argiaquolls	Mollisols.
Perella [6]	Fine-silty, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Renshaw	Fine-loamy, over sandy or sandy-skeletal, mixed, frigid.	Udic Haploborolls	Mollisols.
Salida [1]	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Sioux	Sandy-skeletal, mixed, frigid	Entic Haploborolls	Mollisols.
Storden [1]	Fine-loamy, mixed, mesic	Entic Hapludolls	Mollisols.
Svea	Fine-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols.
Sverdrup	Coarse-loamy, mixed, frigid	Udic Haploborolls	Mollisols.
Tara	Fine-silty, mixed, frigid	Pachic Udic Haploborolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Vallers	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Wadena [1 6]	Fine-loamy over sandy or sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols.
Waukon	Fine-loamy, mixed, frigid	Udic Argiborolls	Mollisols.
Webster [1]	Fine-loamy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Winger	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols.

[1] This soil is a taxadjunct to the series because the mean annual soil temperature is less than 47° F.
[2] This soil is a taxadjunct to the series because it is more loamy than is typical for the series.
[3] This soil is a taxadjunct to the series because it is more silty than is typical for the series.
[4] This soil is a taxadjunct to the series because the surface layer is thin and lighter in color than is typical for the series.
[5] This soil is a taxadjunct to the series because the clay content is less than is typical for the series.
[6] This soil is a taxadjunct to the series because the mollic epipedon is thicker than is typical for the series.

ORDER: Ten soils orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. Two exceptions to this are the Entisols and Histosols, which occur in many different kinds of climate. Table 9 shows that the three soil orders in Pope County are Entisols, Mollisols, and Histosols.

Entisols are light-colored soils that do not have genetic horizons or that have only very weakly expressed beginnings of such horizons. In Pope County this order includes some soils previously classified as Regosols.

Mollisols formed under grass and have a thick, dark-colored surface layer containing colloids dominated by bivalent cations. Soils of this order were formerly called Chernozems and Brunizems.

Histosols formed in wet areas under marsh grass and consist of muck or peat of varying thickness. Soils of this order were formerly classified as organic soils.

SUBORDER: Each order has been subdivided into groups (suborders) primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences produced through the effects of climate or vegetation.

GREAT GROUP: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and other features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that contain a pan that interferes with growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9, because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the great group.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES: The series is a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

General Nature of the County

This section provides general information about Pope County. It discusses the geology, physiography and drainage, climate, farming and other subjects of general interest.

Geology

Pope County is covered by glacial drift and modified glacial drift of the Late Wisconsin glaciation. The glacial ice covered the county about 10,000 years ago. When it receded it left a thick mantle of glacial drift ranging in thickness from 100 to 250 feet.

The geologic structure of Pope County was influenced by two lobes of the Late Wisconsin glaciation. The Wadena lobe entered from the northeast and covered a large part of the county. Later the Des Moines lobe entered the county from the west and overrode the glacial drift of the Wadena lobe.

Pope County has several prominent geologic features. The Alexandria Moraine complex dissects the county from the north-central to the southeastern part. The soils in this area are mainly of the Langhei, Barnes, and Waukon series. The broad, hilly moraine was first formed as a recessional moraine of the Wadena lobe; later it was increased in size as a recessional moraine of the Des Moines lobe. The moraine rises to a height of more than 200 feet above the surrounding land. Several streams, including the East Branch of the Chippewa River and Mud Creek, completely dissect the Alexandria Moraine complex. These streams flow through what appear to be older valleys that were partially filled by the last glaciation. These buried valleys contain several lakes, including Lakes Minnewaska, Emily, Benson, and Gilchrist. In these valleys occur mainly soils of the Mayer series, Muck, and Alluvial land.

In the Alexandria Moraine complex is a prominent range of hills that begin at the eastern end of the Lake Emily valley. They extend 13 miles southeasterly to Lake Linka, and then northeasterly to near the village of Terrace. This range of hills has very steep, uniform slopes and consists mainly of water-sorted sand and gravel. These hills rise to a height of 100 to 150 feet above the surrounding land. The main soils on these hills are those of the Sioux and Renshaw series.

The soils in the western townships, particularly in New Prairie and White Bear Lake Townships, commonly contain a layer of "pink" glacial till. This layer consists of calcareous, light-brown or light reddish-brown loam that ranges in thickness from a few inches to more than 2 feet. Where present, it is at a depth of between 18 and 36 inches. In places this "pink" layer is similar to material deposited by the Superior lobe, which covered parts of northeastern Minnesota. Some of the material from the Superior lobe may have been carried into Pope County and then smeared across the existing soils.

Two large areas of stratified gravel and sand occur in Pope County. The larger area is along the eastern edge of the Alexandria Moraine complex and is about 8 miles wide and 40 miles long. The material in this area was deposited by melt water from the ice sheet that covered the Alexandria Moraine complex. The main soil is Estherville loam.

Several areas resembling plateaus are present in the vicinity of Lake Johanna. These areas are somewhat circular, have steep slopes, and are 50 to 80 feet higher than the surrounding land. These plateaus may be either the deposits of ice-walled lakes or the remains of an earlier landscape.

Prominent kames and eskers occur in an area at the eastern end of the Mud Creek valley in Section 29 of Lake Johanna Township. The eskers are 30 to 40 feet high in places and extend discontinuously for a distance of about 3 miles. The positioning of the eskers indicates that the water flowed in a northeasterly direction.

Several large, abandoned watercourses extend across the outwash area in a northeasterly direction. They range in width from a quarter of a mile to half a mile and are several miles long. Muck and Muck over sand occur in these watercourses.

A second, smaller area of sand and gravel is located in the southwestern part of the county, in Hoff and Walden Townships. Sediments were deposited in this area by water flowing down the glacial Chippewa River. These sediments formed an outwash apron that extended into glacial Lake Benson. They range in size from gravel, which occurs in Walden Township, to mainly well-sorted sand in the southern part of Hoff Township. The main soils in this area are of the Renshaw and Marysland series.

Physiography and Drainage

Pope County is rectangular, 30 miles long and 24 miles wide. It ranges in elevation from 1,450 feet in Leven Township to 1,040 feet in the Chippewa River valley in Hoff Township. Mean elevation in the county is about 1,275 feet.

Most of Pope County is nearly level to gently sloping, but a broad range of hills lies across the central part of the county. It enters the county just west of Lake Reno and extends south and southeast across Minnewaska, Barsness, Chippewa Falls, and Gilchrist Townships and across the southwestern part of Lake Johanna Township.

Except for a small area in the northeastern corner, Pope County lies within the drainage basin of the Minnesota River. Most of Pope County is drained by the Chippewa River, which flows southward through the western townships. The main tributaries of the Chippewa River are the Little Chippewa River, which flows through White Bear Lake and Ben Wade Townships; Outlet Creek, which takes its headwater from Lake Minnewaska and flows through Lake Emily; and the east Branch of the Chippewa River, which flows out from Lake Amelia south into Swift County and joins the Chippewa River near Benson.

In the eastern edge of Pope County, Ashley Creek, a tributary of the Sauk River, has its source in Westport Lake. The northern fork of the Crow River takes its headwaters from Grove Lake.

Climate[4]

Pope County has a midcontinental climate. Summers are warm and moist, and winters are cold and dry. No sharply marked differences in the topography occur in the county, so the climate throughout the county is fairly uniform. Temperature and precipitation data for the county are given in table 10.

The average temperature for December, January, and February is 13.9° F. In the winter of 1935–36, however, an average temperature of 1.6° was recorded for these 3 months. The temperature in most winters drops to 20° below zero, or lower, for 1 or 2 days. In January it can be expected that 2 years in 10 will have at least 4 days when the temperature is 23° below zero, or lower.

[4] By DONALD A. HAINES, State climatologist, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation*

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Days with snow cover of 1.0 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	20	0	42	−23	0.6	0.1	1.0	24	4
February	25	4	44	−17	.7	.1	1.2	24	4
March	37	18	56	−6	1.1	.3	2.0	18	4
April	55	32	75	19	2.1	.6	3.9	4	2
May	69	45	85	31	3.0	1.2	5.5	0	0
June	78	55	91	43	3.9	1.9	6.5	0	0
July	84	60	97	50	3.2	1.2	5.9	0	0
August	82	58	95	47	3.0	1.4	5.5	0	0
September	72	47	90	33	1.9	.7	3.7	0	0
October	61	36	81	21	1.5	.1	2.8	(1)	0
November	40	21	62	−1	1.0	.1	2.1	9	2
December	26	8	42	−15	.6	.1	1.1	19	4
Year	54.5	32			22.6	17.4	26.1	98	

[1] Less than 0.5 day.

The average temperature for June, July, and August is 69.3°. Temperatures as high as 100° or more have been recorded on 50 days in the 30-year period from 1930 through 1959. In July it can be expected that 2 years in 10 will have at least 4 days when the temperature is 97° or higher.

About 75 percent, or approximately 17 inches, of the annual precipitation falls during the growing season, from April through September. Measurable precipitation of at least 0.01 inch can be expected on about 85 days a year, and on 4 of these days, 1 inch or more can be expected. Rainfall at the intensity of about 1 inch an hour can be expected once in 2 years. Annual rainfall has ranged from a low of 15.31 inches in 1933 to a high of 33.48 inches in 1965. The greatest rainfall in any month was in June of 1914.

Measurable snowfall generally comes late in October 1 year in 3. The last measurable snow generally falls in April. Annual snowfall has ranged from 8.1 inches in 1895 to 89.2 inches in 1951.

The growing season is long enough for the crops commonly grown in the county to mature without much damage from frost. The probabilities of certain temperatures occurring in spring and in fall are shown in table 11. This table shows, for example, that 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected to occur later than May 12 in spring and earlier than September 25 in fall (*2*).

Long-term records of humidity, cloudiness, and wind velocity are not available for Pope County, but data from weather stations at Morris in Stevens County are representative of conditions in Pope County. These records show that the average windspeed is about 12 miles an hour. The prevailing direction of the wind is from the northwest in winter and from the south in summer. Relative humidity at noon ranges from about 55 percent in summer to about 72 percent in winter. In a typical year there are 98 days that are clear, 116 days that are partly cloudy, and 151 days that are cloudy.

Much of the rain during the growing season comes in thunderstorms, and about 40 of these occur in the county each year. Some of the thunderstorms are accompanied by hail and damaging winds. Tornadoes are rare. Only eight were recorded during the period 1916–1967.

Settlement

The first permanent settlers in what is now Pope County located in Lake Johanna and Gilchrist Townships in 1861 and 1862. During the Indian uprising of 1862, these first settlers fled to Paynesville and St. Cloud for protection. Many of them, however, returned in 1863 and 1864. In 1866 Pope County was organzied and was named for Gen. John Pope, who had explored the area in 1849.

The early settlers remained where there was a supply of timber and where there was grassland for their livestock. They were mainly of Swedish and Norwegian descent, but later settlers came from Germany, England, and Bohemia.

In 1882 the Little Falls and Dakota Railroad, now a branch line of the Northern Pacific Railroad, was completed across the county. Along this line the towns of Westport, Villard, and Cyrus developed. In 1886 the Soo Line was completed across the county. Along this railroad Sedan, Lowry, and Farwell developed. Glenwood, platted in 1866, was aided in its growth by the arrival of both the Northern Pacific Railroad and the Soo Line.

Pope County has followed the general trend of rural areas in its growth and subsequent decline in population. There was a steady increase in population until about 1950, and since then it has been declining.

Farming

In 1966 there were 1,204 farms, with a total of 355,119 acres, in Pope County. This is slightly more than 80 percent of the land area in the county. The average size of the farms was about 295 acres. The trend during the past two decades has been for the size of the farms to increase and for the number of people on these farms to decrease.

Wheat was the main crop grown by the early settlers in Pope County. Wheat production reached its peak around 1900 and then began to decline. In the past two decades, however, acreage planted to wheat has increased slightly. Before 1900 the acreage in corn was small, but since 1900 it has increased until it is now the main crop. Oats has long been an important crop and still ranks second in acreage. Soybeans were introduced around 1940 and now rank third in acreage. Flax and barley are minor crops. Alfalfa and mixtures of alfalfa and grass are the main hay crops.

Of the acreage planted to crops in Pope County in 1967, 71,200 acres was in corn; 50,100 acres was in oats; 41,400 acres was in soybeans; 8,700 acres was in wheat; 9,000 acres was in flax; and 35,000 acres was in alfalfa and mixtures of alfalfa and grass.

Livestock production was not of great importance in the early development of Pope County. As population increased, and greater marketing facilities became available, production of livestock for food increased. The establishment of creameries in the 1880's helped to increase the number of dairy herds. The production of beef cattle has been important to the economy of Pope County, but in the past two decades the number of dairy herds and dairy cows has decreased. The increase in corn production has helped to increase the production of hogs. The raising of poultry and sheep is of minor importance.

In 1967 in the county there were 53,300 cattle, 24,800 of which were milk cows. There were also 26,700 hogs.

Transportation and Markets

Pope County is served by two railroads. The main line of the Soo Railroad cuts diagonally across the county from the southeast to the northwest and serves Sedan, Glenwood, Lowry, and Farwell. A branch of the Soo Railroad runs north from Glenwood to Alexandria. The Northern Pacific Railroad runs east and west across the county and serves Westport, Villard, Glenwood, Starbuck, and Cyrus.

State Highway 55 crosses the county diagonally from southeast to the northwest and runs parallel to the Soo Railroad. State Highways 14, 29, and 104 are the main roads running north and south. State Highway 28 crosses the county from east to west. State Highway 9 crosses the extreme southwestern part of the county in Hoff Township. There are numerous county hardtop roads and gravel-surfaced county and township roads.

TABLE 11.—*Probabilities of last freezing temperature in spring and first in fall*

Probability	Dates for given probability and temperature							
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower	36° F. or lower	40° F. or lower	50° F. or lower
Spring:								
1 year in 10 later than	Apr. 18	Apr. 28	May 6	May 20	May 27	June 7	June 17	----------
2 years in 10 later than	Apr. 13	Apr. 22	May 1	May 14	May 22	June 2	June 12	----------
5 years in 10 later than	Apr. 1	Apr. 11	Apr. 21	May 4	May 12	May 24	June 2	June 22
Fall:								
1 year in 10 earlier than	Oct. 20	Oct. 10	Sept. 30	Sept. 19	Sept. 11	Aug. 3	Aug. 10	----------
2 years in 10 earlier than	Oct. 26	Oct. 16	Oct. 6	Sept. 24	Sept. 16	Sept. 5	Aug. 18	----------
5 years in 10 earlier than	Nov. 5	Oct. 28	Oct. 17	Oct. 4	Sept. 25	Sept. 16	Sept. 3	July 17

Municipal airports are located at Glenwood and Starbuck.

Most towns have market facilities for small grains, corn, flax, and soybeans. Livestock is shipped by truck to south St. Paul. Creameries are located at Starbuck, Cyrus, Lowery, and Villard.

Community Facilities and Industry

Pope County has three newspapers, which are located in Glenwood, Starbuck, and Cyrus. Hospitals and retirement homes are located in Starbuck and Glenwood. High schools are located at Glenwood, Starbuck, Villard, and Cyrus. Other schools are located at Westport, Lowry, and Farwell.

Although the main industry in Pope County is farming, there are several other industries in the county, mainly in Glenwood and Starbuck. These include factories for the production of machinery, sporting goods, and cement products. There is also a firm that bottles spring water and distilled water.

Literature Cited

(1) AMERICAN ASSOCIATION OF HIGHWAY OFFICIALS.
1961. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 8, 2 v., illus. Washington, D.C.

(2) BAKER, DONALD G. AND STRUB, JOSEPH H., JR.
1963. PROBABILITY OF OCCURRENCE IN THE SPRING AND FALL OF SELECTED LOW TEMPERATURES. Pt. I *in* Climate of Minnesota, Univ. of Minn. Agr. Expt. Sta. Tech. Bul. 243, 40 pp.

(3) BALDWIN, MARK, KELLOGG, CHARLES E., AND THORP, JAMES.
1938. SOIL CLASSIFICATION. U.S. Dept. of Agr. Ybk.: 979–1001, illus.

(4) SIMONSON, ROY W.
1962. SOIL CLASSIFICATION IN THE UNITED STATES. Sci. 137: 1027–1034.

(5) THORP, JAMES AND SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 177–126.

(6) UNITED STATES DEPARTMENT OF AGRICULTURE.
1960. SOIL CLASSIFICATION, A COMPREHENSIVE SYSTEM, 7TH APPROXIMATION. 265 pp., illus. [Supplements issued in March 1967 and September 1968]

(7) ———
1951. SOIL SURVEY MANUAL. Agr. Handbook No. 18, 503 pp., illus.

(8) UNITED STATES DEPARTMENT OF DEFENSE.
1968. UNIFIED SOIL CLASSIFICATION SYSTEM FOR ROADS, AIRFIELDS, EMBANKMENTS, AND FOUNDATIONS. MIL–STD–619B, 30 pp., illus.

Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drift, glacial (geology). Material of any sort deposited by geologic processes in one place after having been removed from another. Glacial drift consists of earth, sand, gravel, and boulders deposited by glaciers and by the streams and lakes associated with them. It includes glacial till, which is not stratified, and glacial outwash, which is stratified.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Ground moraine (geology). Glacial till accumulated beneath advancing ice and deposited from it during its dissolution, rather than aggregated in a thickened belt at the ice edge. The deposit is relatively thin and characteristically forms an undulating plain with gently sloping swells, sags, and closed depressions.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone-derived materials applied to neutralize acid soils. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oystershells, and marl also contain calcium.

Loess. A fine-grained, wind-laid deposit that consists dominantly of silt-sized particles.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many;* size—*fine*, *medium*, and *coarse;* and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Muck. An organic soil consisting of fairly well decomposed organic material that is relatively high in mineral content, finely divided, and dark in color.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Natural soil drainage. Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of medium texture.

Moderately well drained soils have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and commonly have mottlings in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Outwash, glacial (geology). See Drift, glacial.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Peat. Unconsolidated soil material, largely undecomposed organic matter that has accumulated where there has been excessive moisture.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Till, glacial. See Drift, glacial.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated wtih high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable. hard, nonaggregated, and difficult to till.

Type, soil. A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

Variant, soil. A soil that has properties sufficiently different from those of other known soils to justify a new series name, but of such limited geographic area that establishing a new series cannot be justified.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit, read the introduction to the section it is in for general information about its management. For discussion of windbreak suitability groups, refer to pages 63 and 64. Other information is given in tables as follows:

Acreage and extent, table 1, page 7.
Predicted yields, tables 2 and 3, pages 58 and 60, respectively.
Interpretations for recreational development, table 6, page 67.
Engineering uses of soils, tables 7 and 8, pages 72 through 99.

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group
			Symbol	Page	Number
Af	Alluvial land	6	VIw-1	57	10
As	Arveson sandy loam	8	IIIw-4	54	7
BaA	Barnes loam, 0 to 2 percent slopes	8	I-1	45	1
BbB2	Barnes-Langhei loams, 2 to 6 percent slopes, eroded	8			
	Barnes loam	--	IIe-1	46	1
	Langhei loam	--	IIe-1	46	5
BbC2	Barnes-Langhei loams, 6 to 12 percent slopes, eroded	9			
	Barnes loam	--	IIIe-1	50	1
	Langhei loam	--	IIIe-1	50	5
BdB2	Barnes-Langhei-Renshaw loams, 2 to 6 percent slopes, eroded	9			
	Barnes loam	--	IIe-1	46	1
	Langhei loam	--	IIe-1	46	5
	Renshaw loam	--	IIe-1	46	6
BdC	Barnes-Langhei-Renshaw loams, 6 to 12 percent slopes	9			
	Barnes loam	--	IVe-1	54	1
	Langhei loam	--	IVe-1	54	5
	Renshaw loam	--	IVe-1	54	6
Be	Bearden silt loam, 0 to 2 percent slopes	10	IIe-4	47	5
Bh	Blue Earth silt loam	11	IIIw-5	54	10
Ca	Canisteo loam	11	IIw-2	48	4
CmB	Clarion loam, 2 to 6 percent slopes	12	IIe-1	46	1
CmC2	Clarion loam, 6 to 12 percent slopes, eroded	12	IIIe-1	50	1
Cn	Clontarf sandy loam, 0 to 2 percent slopes	13	IIIs-3	52	8
Co	Colvin silty clay loam	13	IIw-2	48	4
Cp	Colvin silty clay loam, depressional	13	IIIw-2	53	4
DaB	Darnen silt loam, 0 to 4 percent slopes	14	I-1	45	1
DcA	Dickinson sandy loam, 0 to 2 percent slopes	14	IIIs-2	52	6
DcB	Dickinson sandy loam, 2 to 6 percent slopes	15	IIIs-2	52	6
DlA	Doland silt loam, 0 to 2 percent slopes	15	I-1	45	1
DlB	Doland silt loam, 2 to 6 percent slopes	15	IIe-1	46	1
Es	Estelline silt loam, 0 to 3 percent slopes	16	IIs-1	48	2
Et	Estelline silt loam, moderately well drained variant	17	IIs-1	48	8
EvA	Estherville loam, 0 to 2 percent slopes	17	IIIs-1	52	6
EvB	Estherville loam, 2 to 6 percent slopes	17	IIIe-3	52	6
EvC2	Estherville loam, 6 to 12 percent slopes, eroded	17	IVe-2	55	6
EwA	Estherville loam, thick solum, 0 to 2 percent slopes	18	IIs-1	48	2
EwB	Estherville loam, thick solum, 2 to 6 percent slopes	18	IIe-3	46	2
FlA	Flandreau silt loam, 0 to 2 percent slopes	18	IIs-1	48	2
FlB	Flandreau silt loam, 2 to 6 percent slopes	18	IIe-3	46	2
FoA	Fordville loam, 0 to 2 percent slopes	20	IIs-1	48	2
FoB	Fordville loam, 2 to 6 percent slopes	20	IIe-3	46	2
FrB2	Forman clay loam, 2 to 6 percent slopes, eroded	20	IIe-1	46	1
FrC2	Forman clay loam, 6 to 12 percent slopes, eroded	20	IIIe-1	50	1

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Windbreak suitability group Number
Gn	Glencoe silty clay loam	21	IIIw-1	53	3
Hc	Hamar sandy loam	21	IIIw-4	54	7
Hd	Hamerly loam, 0 to 3 percent slopes	22	IIe-4	47	5
Hv	Hecla loamy sand, 0 to 3 percent slopes	23	IVs-1	55	6
La	Lake beaches, sandy	23	VIw-1	57	7
Lb	Lake beaches, loamy	23	VIw-1	57	10
Lc	Lamoure silt loam	23	IIw-2	48	4
Lh	Lamoure silt loam, wet	23	VIw-1	57	10
Lk	Lamoure complex	24			
	Lamoure silt loam	--	IIw-2	48	4
	Lamoure silt loam, wet	--	IIw-2	48	10
L1E	Langhei loam, 18 to 25 percent slopes	24	VIe-1	56	5
L1F	Langhei loam, 25 to 40 percent slopes	24	VIIe-1	57	5
LmF	Langhei stony loam, 6 to 40 percent slopes	24	VIIe-1	57	5
LnB2	Langhei-Barnes loams, 2 to 6 percent slopes, eroded	24			
	Langhei loam	--	IIe-2	46	5
	Barnes loam	--	IIe-2	46	1
LnC2	Langhei-Barnes loams, 6 to 12 percent slopes, eroded	25			
	Langhei loam	--	IIIe-2	51	5
	Barnes loam	--	IIIe-2	51	1
LnD2	Langhei-Barnes loams, 12 to 18 percent slopes, eroded	25			
	Langhei loam	--	IVe-1	54	5
	Barnes loam	--	IVe-1	54	1
LoD2	Langhei-Barnes-Sioux complex, 12 to 18 percent slopes, eroded	25			
	Langhei loam	--	VIe-1	56	5
	Barnes loam	--	VIe-1	56	1
	Sioux loamy sand	--	VIe-1	56	9
MbC	Maddock loamy sand, 6 to 12 percent slopes	26	VIs-1	57	6
MbE	Maddock loamy sand, 12 to 25 percent slopes	26	VIIs-1	57	6
MdA	Maddock sandy loam, 0 to 2 percent slopes	26	IVs-1	55	6
MdB	Maddock sandy loam, 2 to 6 percent slopes	26	IVs-1	55	6
Mf	Malachy sandy loam, 0 to 2 percent slopes	27	IIIs-3	52	8
Mk	Marsh	27	VIIIw-1	57	10
Ml	Marysland loam	27	IIw-3	49	7
Mn	Mayer loam	28	IIw-3	49	7
Mo	Mayer loam, depressional	28	IIIw-3	53	7
Mr	Mayer loam, sandy subsoil variant	28	IIw-3	49	7
Ms	McIntosh silt loam, 0 to 2 percent slopes	29	IIe-4	47	5
Mt	Muck	29	IIIw-5	54	10
Mu	Muck, calcareous	29	IIIw-5	54	10
Mv	Muck, calcareous, seeped	30	VIIIw-1	57	10
Mw	Muck, calcareous, over loam	30	IIIw-5	54	10
Mx	Muck, calcareous, over sand	30	IVw-1	56	10
My	Muck over loam	30	IIIw-5	54	10
Mz	Muck over sand	30	IVw-1	56	10
Nc	Nicollet loam, 0 to 3 percent slopes	31	I-1	45	1
NuA	Nutley silty clay loam, 0 to 2 percent slopes	31	IIe-1	46	1
NuB	Nutley silty clay loam, 2 to 6 percent slopes	32	IIe-1	46	1
Om	Oldham silty clay loam	32	IIIw-2	53	4
Os	Osakis sandy loam, 0 to 2 percent slopes	33	IIIs-1	52	6
Pa	Parnell silty clay loam	33	IIIw-1	53	3
Pf	Parnell and Flom silty clay loams	33	IIw-1	48	3
Pr	Perella silty clay loam	34	IIw-1	48	3

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Windbreak suitability group Number
ReA	Renshaw loam, 0 to 2 percent slopes	34	IIIs-1	52	6
ReB	Renshaw loam, 2 to 6 percent slopes	35	IIIe-3	52	6
ReC2	Renshaw loam, 6 to 12 percent slopes, eroded	35	IVe-2	55	6
SdB	Salida sandy loam, 0 to 6 percent slopes	35	IVs-2	55	9
SdC2	Salida sandy loam, 6 to 12 percent slopes, eroded	35	IVs-2	55	9
SeF	Salida gravelly sandy loam, 12 to 35 percent slopes	36	VIIs-1	57	9
SlB	Sioux sandy loam, 0 to 6 percent slopes	36	IVs-2	55	9
SlC2	Sioux sandy loam, 6 to 12 percent slopes, eroded	36	IVs-2	55	9
SoF	Sioux gravelly sandy loam, 6 to 35 percent slopes	36	VIIs-1	57	9
SrE2	Storden-Clarion loams, 12 to 25 percent slopes, eroded	37			
	Storden loam	--	IVe-1	54	5
	Clarion loam	--	IVe-1	54	1
SuA	Svea loam, 0 to 2 percent slopes	37	I-1	45	1
SuB	Svea loam, 2 to 4 percent slopes	37	IIe-1	46	1
SyB2	Sverdrup sandy loam, 2 to 6 percent slopes, eroded	38	IIIs-2	52	6
SyC2	Sverdrup sandy loam, 6 to 12 percent slopes, eroded	38	IVe-2	55	6
SzA	Sverdrup loam, 0 to 2 percent slopes	38	IIIs-2	52	6
Ta	Tara silt loam, 0 to 3 percent slopes	39	I-1	45	1
To	Tonka silt loam	39	IIIw-1	53	3
Va	Vallers silty clay loam	40	IIw-2	48	4
Wa	Wadena loam	40	IIs-1	48	2
WbA	Waukon loam, 0 to 2 percent slopes	41	I-1	45	1
WbB	Waukon loam, 2 to 6 percent slopes	41	IIe-1	46	1
WbC	Waukon loam, 6 to 12 percent slopes	41	IIIe-1	50	1
WbD	Waukon loam, 12 to 18 percent slopes	41	IVe-1	54	1
WdB2	Waukon clay loam, 2 to 6 percent slopes, eroded	42	IIe-1	46	1
WdC2	Waukon clay loam, 6 to 12 percent slopes, eroded	42	IIIe-1	50	1
We	Webster loam	42	IIw-1	48	3
Wn	Winger silty clay loam	43	IIw-2	48	4

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.